Review of "*The potential of InSAR for assessing meltwater lake dynamics on Antarctic ice shelves*" by Weiran Li et al.

Li et al. assess the utility of synthetic aperture radar interferometric (InSAR) techniques (coherence, phase) to track the seasonal evolution of supraglacial lakes across two East Antarctic ice shelves. While similar techniques have previously been applied to Arctic regions (e.g. Antonova et al., 2016), this study presents the first application of C-band InSAR observations for lake monitoring in the Antarctic. Although the use of InSAR is found to be limited in summer due to extensive surface melting (resulting in phase decorrelation), the authors show that, compared to backscatter (and supplementary optical imagery) alone, coherence and phase information can provide important additional insights into the exact dimensions and timing of lake evolution during non-summer months. These insights have importance for understanding the processes behind ice-shelf weakening (and potential destabilization) in a changing climate, with implications for global sea-level rise. In this regard, I believe that the results presented in this manuscript will be of interest to the general readership of The Cryosphere although, prior to publication, I recommend moderate-to-major revisions. I outline my reasoning for this decision in the general comments below.

General Comments

My main concern pertains to the overall readability of the manuscript. While it is clear that the authors understand the background literature, methods, key results and implications of their research, their writing style is in general unconventional for a piece of scientific writing, insofar as it is highly verbose, often grammatically and/or typographically incorrect and, hence, difficult to follow/comprehend from a reader's point of view. This is further confounded by what appears to be inconsistencies in the clarity/style of writing adopted in different sections of the manuscript, missing information needed to fully understand the datasets and/or logic of arguments presented, and the occasional lack of relevant citations throughout the text (see my specific and technical comments for further details).

To address these issues, I recommend that all coauthors take the time to carefully restructure the wording of the manuscript to: a) more logically explain (and justify fully) the choice of all techniques and methodological decisions used/taken, b) correct typographical/grammatical errors and, c), cut down and hence improve the overall focus/narrative of the text. To assist the authors in this regard, I have made some suggestions on how the first two paragraphs of the introduction could be rewritten (see bottom of this document). If needed, the authors may also find the following resource (https://www.the-cryosphere.net/submission.html#english) and links therein helpful.

Specific Comments

Title. 'InSAR' is an abbreviation and hence inappropriate for use in a title. Suggest rephrasing title to: 'The potential of synthetic aperture radar interferometry for assessing meltwater lake dynamics on Antarctic ice shelves' or similar instead. (see also my comments regarding Line 246).

Line 2. Suggest replacing 'Yet' with 'Despite these phenomena'. Replace 'or' with 'and'.

L3. Suggest either ending sentence after 'limited', or briefly explaining what the limitations of optical satellite imagery are here.

L8. Change 'The analysis' to 'Our analysis'. At end of this sentence, change 'confounded' to either 'hard to distinguish' or 'indistinguishable'. Then change next sentence to: 'Despite this

finding, we show using a combination of backscatter and InSAR observations that lake dynamics can be effectively captured during other non-summertime months'.

L11. Sentence beginning 'In particular'. For conciseness, suggest merging this and next sentence to: 'Moreover, our findings highlight the utility of InSAR-based observations for discriminating between refrozen ice and subsurface meltwater, and indicate the potential for phase-based detection and monitoring of rapid meltwater drainage events'.

Introduction. While this introduction is well researched and all of the key information/literature is there, my sense is that it is rather verbose and/or repetitive and could be shortened considerably. For readers with little/no remote sensing expertise, I'm also a little concerned that there are multiple logic gaps which would make this difficult to follow. See my suggested rewrite of the first two paragraphs (bottom of document) to get a sense of how this could be rewritten for brevity and clarity.

L56. Remove 'The' and begin sentence 'Coherence is considered an indicator of changes'. Note also that phase difference does not correspond to the 'average' difference, but a very precise measurement of whole wavelength (and some fractional component) range difference. Suggest editing the rest of the sentence to reflect this.

L59. Sentence beginning 'This combination'. Who expects this? Add a reference to back up this claim, otherwise say 'We expect this' or similar.

L67. Suggest changing to: "However, the value added using InSAR for such applications has not yet been examined".

L68-71. The structure of this paragraph is rather difficult to follow. Suggest beginning with "In this paper, we assess the potential of C-band backscatter and InSAR data to … For this purpose, we use a combination of backscatter, coherence and phase information to monitor recent meltwater features over two East Antarctic locartions – the Amery and Roi Baudouin (RBIS) ice shelves – using data collected by Sentinel-1a/b in 2017/2018. To supplement the interpretation of our (In)SAR-based analyses, we also utilize spatially and temporally collocated optical satellite data.

L75. Sentence is very long and could be split in two after reference to Lenaerts et al. (2016).

L81. Why was a lake dataset not available? The reader shouldn't need to guess this, so state explicitly here. (I think you mean that no previously published dataset exists?). When mentioning Landsat data, also point readers to Section 2.2 for reference.

L83. Sentence beginning 'Our lake class'. If my understanding of the above is correct, then this sentence is confusing as it suggests that a preexisting lake dataset does indeed exist. If so, why didn't you use that here? Please either edit sentence of clarify or remove from the text.

Figure 1. This is a nice figure, but please add latitude/longitude information to each panel so that readers can easily deduce locations. Please also consider showing two additional, zoomed out panels showing the location of each subset within both ice shelves, and (if necessary) in these and all pre-existing panels, add the ice sheet grounding line for reference (e.g. https://doi.org/10.7280/D1VD6G). (I know that the lower right panel shows this to a certain extent, but it's difficult to see details. In general, I also find the labels rather small and difficult to locate, so these could also be enlarged (plenty of space on figures to do this).

Figure 1 caption. Please define RBIS in full in caption. Replace 'close ups' with 'inset' or 'detail'. Insert comma after 'panels'. Change 'delineated in black curves' to 'delineated as black

curves'. In next sentence, what does 'indices' refer to? Labels? If so use 'labels' instead for clarity. Suggest rephrasing following sentence to read: "…are also delineated for comparison against backscatter intensity and coherence values observed over lakes (Fig. 2)' or similar. For general readability, next sentences could/should read: 'Panel R2 illustrates the lake feature shown in Figure [insert number here]. Inset shows location of the analyzed locations'. Please also state in caption which band/band combinations are shown (Landsat).

Table 1 caption. Should read '… used in this study'.

L99. Please add more information (and references if necessary) on how the images were denoised, calibrated and corrected here. (The reader shouldn't have to look it up for themselves).

L92. I presume this is a typo and should say 10x10 m resolution (i.e. the native resolution of IW GRDH; https://sentinels.copernicus.eu/web/sentinel/technical-guides/sentinel-1-sar/products-algorithms/level-1-algorithms/ground-range-detected/iw)? If not, then how does this impact the rest of your backscatter analyses?

Also, if my understanding is correct then NRCS is identical to radiometrically calibrated, sigma-nought (σ^0) backscatter imagery. Sigma-nought backscatter is the much more commonly adopted term in the geosciences (RCS more so in engineering), so given the likely readership of The Cryosphere, I would instead refer to σ^0 in place of NCRS here and universally throughout the manuscript. Following this point, be careful that the imagery you downloaded from Google Earth Engine isn't already in sigma-nought format, as the 'radiometric calibration' you mention GEE perform above may imply.

L95. Confusing. If you have multi-looked the SLC to create your own GRD/Sigma-nought imagery then why did you bother downloading GRD imagery from GEE? Clarify here.

L97. Why is a geoid only used for Amery? I expect this is a typo?

L98+ This is a good example of missing methods I mentioned in my general comments. Here, I am surprised to see absolutely no information about how the authors generated their interferograms. This must be added, including, as a minimum, information on e.g. temporal/perpendicular baselines used, type of processing performed (I assume single-pass DInSAR?) and (if used) any DEM used to remove topographical phase.

L99-100. Again, for clarity/reproducibility purposes, much more info should be included here on e.g. the band/band combinations used, pixel resolutions of the data, and any relevant pre-processing steps you applied to your Landsat imagery. Stating that you simply downloaded them off GEE is not appropriate for a scientific paper.

L105. I think it's important to explicitly state here that for each class type analyzed, you calculated the mean and standard deviation backscatter for all observed features. As written this is not obvious, and leads to confusion over what the difference is between 'lake class' and the 'individual lakes' (for this reader at least …). This could also be made more explicit in the caption of Figure 2.

L106. For clarity, 'mono-dimensional' should be changed to 'cross-sectional'.

L107. Repetition of coherence, NCRS and phase. Suggest restructuring sentence to avoid this.

L112. Suggest changing to: 'The mean sigma-nought timeseries of lakes, snow and ice (cf. Section 2.2) display strong seasonal variability, consistent with the changing nature of both

surface snow and ice properties and the evolution of supraglacial lakes through time (Figure 2). On Amery Ice Shelf, our observations reveal…'.

L13. This is written in an odd manner which implies that snow transforms into lakes and then ice, which is not what the authors intend to say. What I think they mean to say is that snow, lakes and ice for the most part display different (though reasonably constant) backscatter properties throughout the year, with the exception of JF when the backscatter associated with snow and lakes fall rapidly.

L116-125. To shorten the text here, I question whether the authors even need to discuss (and, in Figure 2, show) the individual lakes because for the most part, the average of multiple mapped lakes makes seems to support their arguments just as well. In this regard the individual lake observations are a slight distraction from the overall story revealed by the class averages, so I think they could probably be removed. (as the authors show, there is significant variability from one lake to the next, so focusing in on specific lakes only serves to deviate from what's happening on the whole). This is also largely true for the coherence discussion of RBIS a and f in Section 3.2, as your later coherence images (Figure 7) in any case demonstrate the process of refreezing in a much more convincing way).

L126-134. For clarity, suggest editing sentence to say '…of select cross-sectional transects. In the case of both RBIS 'a' and Amery 'd' (location shown in Figure 1), for example, backscatter timeseries show significant inter-annual variation (Figure 3)'.

L129. 'Border of low NRCS and inner areas of high NRCS'. Revise this sentence to explicitly state that this refers to the edge and central regions of the lake, respectively.

L136-152. These are clear, well written paragraphs. They are logical and concise, and could be considered a model for how the rest of the manuscript should be written.

Figure 2. See my comments regarding L116-125 above. If the authors choose to retain the analysis of individual lake features, then they should make the lines thicker as these are currently very difficult to see both on-screen and in print. To enhance visibility of these lines, I'd also consider making the standard deviation ribbons more transparent as these currently dominate/clutter the figure. As per Figure 1, I also think the labels (and legend especially) should be made bigger/more prominent.

For the coherence plots (and to a lesser degree sigma-nought), I wonder if the high frequency variability discussed by the authors could be smoothed out using something like a running mean? While this variability is interesting, it's a little distracting, and is later largely ignored in the text anyway.

Figure 2 caption. Sentence should read '… over the Amery and Roi Baudouin ice shelves (see Fig. 1 for locations). Change 'Moments …' with 'Times with a lack of 6/12-day…'.

Figure 3. As per Figs 1 and 3, please make all labels larger. Please also add lat/longs to both maps along with scalebars. Also consider zooming both images to show more detail over lakes (bottom right panel especially).

Figure 3 caption. Move '(see Fig. 1)' to end of sentence, and change to '(see Fig. 1 for locations). Add comma before 'respectively'. Next sentence should also say '… over a three-month period'. In next sentence, should read: '…of the feature and its surroundings …'.

Figure 4. Nice figure! As above regarding label size.

Figure 4 caption. Remove 'synoptic' (incorrect usage in this context) in first sentence, and cross-reference Fig. 1 for location at end. In next sentence, remove 'the' proceeding

coherence, and add '… and resulting phase difference interferograms are shown …'. In next sentence, should say 'The high frequency fringes surrounding each lake represent a convolution of both ice flow and tidal motion'. In the last sentence, please state which band/band combinations are shown (Landsat).

Figure 5. Really nice figure, but please add lat/longs and scalebars.

Figure 5 caption. Unnecessary use of 'right' which should be removed. In the next sentence, change 'hereby' to 'hereafter'. In the following sentence, change 'reported' to 'shown (right panels)'. Please also state which band/band combinations are shown.

L147. I think this should say 'between Oct. 2017 and Jan. 2018'. Change 'polygons' to 'surveyed snow, ice and lake areas'.

L154. Amery Ice Shelf.

L159. Replace 'brighter' with 'greater'.

L172. Why 'possibly'? Provide evidence to justify claims here. (Also, RBIS is a rather slow flowing ice shelf, so horizontal displacement should not influence phase coherence over 12 days as much as one might think (see Mohajerani et al. (2021) who were able to map GLs across this region Antarctica with good coverage using double difference InSAR. This technique requires almost perfect coherence, suggesting 12 days is more than sufficient here).

In the next sentence (beginning 'In Oct. 17…'), I think better referencing to Figures 2 and 5 is needed as I don't see any change in coherence from Figure 5 alone.

L176. Change tense to be consistent with the rest of the paragraph. Also, while what you go on to say in Lines 176-177 is technically true, visually I can't tell the difference between the lakes you are discussing and the drainage network. Suggest rewriting this sentence for clarity to specifically emphasize the observed change from a lake to a (presumably) connected drainage network through time.

This is a really nice observation by the way, demonstrating in a compelling manner the utility of coherence to see what simple optical and/or backscatter images cannot.

L179. Suggest rewriting to begin: 'Interferometric phase difference maps (Figure 4) emphasize… Amery ice Shelf.

L180. Initially I didn't see any fringes you refer to (c/w Amery c for example) given the dominance of the high frequency (ice flow) fringes surrounding the lakes, but then I realized you meant the very low frequency fringes on the lakes themselves (~1 cycle of -π to π only). I suggest you state this more clearly (and perhaps label the figure accordingly) so that readers don't incorrectly focus in on the high frequency fringes.

L182. Edges of what? I can work out what you mean, but this can be written more clearly for ease of reading. Possibly also consider citing appropriate figures and panels.

L183. Suggest writing as '….. increase through time indicates the presence of lakes until October 2017, followed… in November of that year. Consistent with our InSAR-based observations Landsat …'.

L179-203. In general, this is another clearly written and easy to comprehend series of paragraphs compared with the earlier section of the manuscript.

L179-186. Regarding Amery Ice Shelf, what (if anything) can we learn about the detection of the hydrological network that is clearly visible in Figure 4 (top row), and which disappears after

March 2017 in the coherence images? (suggesting formation between Mar 11 and 17th and persistent presence (freezing?) thereafter). This is a visually striking feature in the center of these panels that I was surprised to see no discussion of here and/or in Section 3.2.

L187. I'm not quite sure I follow this, as the color scheme always goes from blue to blue. Suggested rewriting for clarity.

L198. How big was this uplift? I think that would be a valuable addition here, and can be estimated either through unwrapping the phase or counting the fringes.

L190. And presumably some tidal component, as *I think* tides haven't been removed? (see also my comments on the omission of any methods detailing exact InSAR processing above).

L194-203. Great series of observations.

Figure 6. Nice figure, but please add lat/longs and scalebars to all panels.

Figure 6 caption. Replace 'interferometric phases' with 'interferometric phase'. For brevity, suggest rewording next sentence as 'Two near-contemporaneous Landsat 8 panchromatic (band 8) images are also shown (right panels)'.

L201. Replace 'starting at the edges' with 'towards the center of the lake' or similar.

Figure 7. Very nice series of observations! Enlarge labels and add lat/longs and scalebar, though.

Figure 7 caption. Replace 'interferogram phases' with 'interferograms' or similar. Please also state which band/band combinations are shown for Landsat imagery.

L204. I'm not sure I completely follow what you're trying to say here, as the sentence contains a grammatical error. Suggest rephrasing for greater clarity.

L205. Suggest beginning this section like: 'Using SAR-based observations acquired across two East Antarctic ice shelves, we present evidence of the utility of backscatter …'.

L213. Change 'Coherence' to 'Interferometric coherence'.

L215. And all other types of SAR SLC data … not just that acquired by Sentinel-1.

L222. I think its important to stress here that low coherence isn't just about refreezing (or not). Radar waves are fully attenuated by water, so you will always get poor coherence as long as there is water. The authors should rephrase this sentence to reflect this point.

L229. This sentence may lead to confusion as it implies water volumes can be calculated using InSAR techniques. Suggest rephrasing to articulate the intended point more clearly.

L232. For consistency with the text above, suggest changing to 'affected by tidal and horizontal motion'.

L237. Again, I think it'd be really nice to see an estimate of the uplift here, derived from either fringe counting or unwrapping the phase (see also my comments on L198).

L241. Amery Ice Shelf.

L243. Argument regarding line-of-sight observations only. This is actually only true for Sentinel-1 which, at present, only has one look direction over these ice shelves. Sentinel-1 (or any other sensor for that matter) collected in both ascending and descending orbit could deconvolve those parameters potentially yielding a better impression of subsidence/uplift, or

at the very least a different (and possibly validatory) view of the lake dynamics relative to that gleaned from a single look direction.

Suggest rephrasing the sentence to stress these points, and refocus the sentence away from Sentinel-1 'only' towards a more broad discussion of the different SAR sensors that could possibly be used.

L244. I wonder to what extent this sentence is true, since more complicated processing techniques like double-difference InSAR (e.g. Mohajerani et al.; 2021) could presumably help to cancel out ice flow signals. De-tiding observations using a tidal model could also remove vertical motion due to tide (see, for example, MacMillan et al., 2012). Did the authors investigate the applicability of these techniques for improving signal-to-noise over the lake areas? (I'm not suggesting this necessarily needs to be done if not, but I feel a more nuanced/careful discussion of how ice/tide displacement could possibly be mitigated to lake detection easier should be included here).

L246. To conclude this section, I think there's big scope to include one or two sentences on the potential advantages of 'next-generation SAR' remote sensing capabilities for lake monitoring. This could involve a discussion of the <6-day imaging capabilities afforded by the launch of Sentinel-1c (~2022), and/or the upcoming (2023) launch of the NASA-ISRO SAR mission (NISAR). While the latter will have a repeat pass time of 12 days over the polar regions, its dual-wavelength (L- and S-band) imaging capabilities may have good potential to circumvent confounding issues such as snow blow and other atmospheric effects, quantify thin/forming ice lid thicknesses etc.

If the authors do not wish add such a discussion, then I recommend editing the title of the study to be sensor specific, e.g. 'The potential of Sentinel-1a/b synthetic aperture radar interferometry for assessing meltwater lake dynamics on Antarctic ice shelves'. (see also my comments regarding the title, L243 and L261-265 above).

L248. I think this sentence could (and should) be snapper. Suggest rephrasing to 'This study has provided insight into the utility of InSAR for monitoring meltwater lake dynamics' or similar.

L261-265. This is largely repetition of Lines 238-246 which I think can probably be significantly shortened and merged with Lines 266-268. Suggest something like: 'Despite noted limitations to current Sentinel-1 InSAR imaging over parts of Antarctica, we show that InSAR provides promising potential for monitoring meltwater lake dynamics beyond that afforded by conventional, backscatter-only, analyses. Such potential could pave the way for …'.

Technical Corrections (typological and grammatical errors etc.)

Referencing. I have noticed multiple inconsistencies in the manuscript. Please ensure referencing style is consistent throughout and adheres to The Cryosphere's specific referencing format (https://www.the-cryosphere.net/submission.html#manuscriptcomposition).

L5. Incorrect grammar and sentence structure. Suggest rephrasing to: 'In two case study regions over the Amery and Roi Baudouin ice shelves, East Antarctica, we examine spatial and temporal variations in SAR backscatter intensity and interferometric (InSAR) coherence and phase over several lakes derived from Sentinel-1a/b C-band SAR imagery.

L15. Insert commas before and after 'however'.

L55. ‘By a certain time’ is colloquial. Suggest ‘by a particular temporal baseline’ or similar instead.

L65. Remove ‘basically’ (colloquial usage inappropriate for scientific writing).

L75-79. These sentences are repetitive and could easily be merged for conciseness. Also, in the last sentence, I think it’s important to explicitly state why you delineated polygons of surrounding snow and ice, as this is unclear.

L88. Insert comma after ‘For both products’. At end of sentence, also add citation to back up this statement.

L99. Pronouns are not to be preceded by ‘the’, so remove ‘the’ before Google Earth Engine. (Also true for the likes of ‘the Amery Ice Shelf’, ‘coherence’ etc.).

L102. Add comma after ‘dynamics’. At end of sentence, explicitly state where you perform this analysis (i.e. over the lakes and control (snow/ice) sites). For clarity, this should probably also involve merging the following sentence.

L105. Insert comma after ‘purpose’. (Note: punctuation errors of this type are a recurring issue and one that I encourage the authors to carefully correct for throughout the manuscript).

L136. ‘Amery ice shelf’ is a pronoun and so should be capitalized. Note that this correction should be carefully applied to all pronouns in the manuscript.

L150. Insert commas before and after ‘however’.

L166. Insert comma after ‘gradual’. Regarding the next sentence, I suggest also labelling the circular feature you refer to in the figure, as it took me a while to recognize exactly what you mean.

L169. Reference Fig. 5 in the first sentence. The second sentence is also grammatically incorrect and should be edited to state that routine Sentinel-1 coverage commenced in 2017 and to date only acquires data with a repeat-pass of 12 days.

L172. Should read ‘…, with only intermediate sigma-nought values’.

L214. Should say ‘assess’.

L215. Remove ‘such as Sentinel-1’.

L228. To maintain the flow of the text here, suggest rephrasing this sentence to: ‘Beyond coherence, we also demonstrate the potential of interferometric phase for assessing … in areas of high coherence’.

L231. Suggest changing ‘instant’ to ‘rapid (sub-weekly) meltwater events’, since changes over 6 days can hardly be classified as instant.

L233. I think this should say ‘…an easier detection of stable ice and lake refreezing than coherence and backscatter intensity …’?

L235. Incorrect grammar/sentence tense. Suggest rewording to: “While InSAR-based techniques show clear potential for monitoring meltwater lake evolution, there are several key limitations associated with this technique compared with conventional optical- and SAR backscatter-based imaging. First, InSAR requires …’.

L240. Replace ‘may’ with ‘can’.

L241. ‘day’ should read ‘days’. Also, suggest rewording ‘Due to this difference’ to ‘Due to these differing imaging times’ or similar.

L253. Sentence beginning ‘A generalization’. Reword to ‘We show that meltwater detection using backscatter is, however, not straightforward, as meltwater lakes often …’.

L255. Replace ‘context’ with ‘circumstance’. Also suggest removing ‘i.e. the coherence and interferogram phases’. (this is unneeded technical info for the conclusion).

Above, the authors could also consider rephrasing the text to offer a more well-rounded discussion on the application of SAR in general, rather than specific application of Sentinel-1 data (see my comments regarding title, L243 and L246).

L256. ‘Besides’ should not be used to begin a sentence. Replace with: ‘In addition, we show that InSAR-derived information can also be used to observe meltwater lake evolution (and potential drainage) with high accuracy beyond that afforded by conventional backscatter or optical satellite imaging’ or similar. Then begin next sentence with: ‘Specifically, InSAR coherence information allows for the detection of changes in the …, while interferometric phase can effectively track the spatial and temporal evolution of ice refreezing. Maps of interferometric phase moreover allow for the detection of abrupt lake drainage (or filling) events via changes in the relative displacement of the surface between successive SAR passes’.

L274. I think this should say ‘WL was responsible … processing and analyzing the results …’.

L278. Remove NSF-OPP awards and rest of lines 279 and 280 as these are not relevant to this study.

L322. Please cite final (non-TCD) publication.

Suggested rewriting of introduction (red = suggested rewording).

Widespread surface meltwater ponding has been observed on Antarctic ice shelves over the past ~X decades (Kingslake et al., 2017). Through seasonal formation and draining of supraglacial lakes, which have the potential to fracture and weaken ice shelves through repeated compression and uplift, respectively (Banwell et al., 2013), such phenomena may have important implications for ice-shelf hydrofracture and collapse (add reference to previous hydrofracture studies here). Therefore, accurately observing the spatial and temporal evolution (filling, drainage or refreezing) of such lakes is pertinent to elucidating the future stability and response of the Antarctic Ice Sheet to climate change.

Given the remote location, widespread area, and harsh climatic conditions in which these lakes form, satellite remote sensing has become the primary method of observing their evolution and dynamics (insert references to back up this claim here). Previous studies have exploited various satellite remote sensing data sources to observe these phenomena; for example, Kingslake et al. (2017) presented an overview of the Antarctic-wide meltwater hydrological network by combining Landsat, WorldView and Aster optical satellite imagery together with historic (pre-satellite) aerial photography. Other work has combined both optical and synthetic aperture radar (hereafter SAR) imagery to detect meltwater features in both Greenland and Antarctica (Benedek and Willis; 2021; Dirscherl et al., 2021), including the detection of subsurface meltwater across East Antarctica’s Roi Baudouin Ice Shelf (RBIS; Lenaerts et al., 2016). Such subsurface melting is not detectable from optical-based imagery

alone (#add reference here), emphasizing the potential utility of SAR to better detect total surface meltwater presence.

Despite the potential of optical and SAR imagery in observing surface meltwater, both sensor types have limitations over Antarctica. Polar night and cloud cover, for example, limit data coverage in optical based imagery (Selmes et al., 2013; Williamson et al., 2017), whereas the operating frequencies and active-source configuration of SAR sensors allow for all-weather, day-night imaging (#add reference here). Relative to intuitive representation of meltwater features detected by optical sensors, however, the interpretation of SAR imagery can be complex due to ambiguous backscatter returns and/or image geometry effects (e.g. Fahnestock et al., 1993; Miles et al., 2017; add reference pertaining to geometry effects, as this is another key limitation of SAR interpretation). While cross-polarised (HV or VH) backscatter intensity SAR images generally provide a better contrast between water and ice than single polarization (e.g. HH) images (Miles et al., 2017), such images aren't necessarily always available over Antarctica (#citation possibly of Sentinel-1 acquisition strategy document).

Papers cited in this review

McMillan, M. et al. (2012). Mapping ice-shelf flow with interferometric synthetic aperture radar stacking. Journal of Glaciology, doi:10.3189/2012JoG11J072.

Mohajerani, Y. et al. (2021). Automatic delineation of glacier grounding lines in differential interferometric synthetic-aperture radar data using deep learning, Scientific Reports, https://doi.org/10.1038/s41598-021-84309-3.