

Response to Referee 1 on tc-2021-169

We appreciate Referee 1 for additionally reviewing and commenting the manuscript. Please find the item-by-item reply below, with the original comments in *italics* and the responses in blue.

I commend the authors for doing a fine job at addressing my concerns and for revising the manuscript accordingly. The manuscript is now much improved, and I believe that the addition of both the ERA5 precipitation and SSMIS passive microwave-derived melt estimates (added in response to some of Reviewer 2's concerns) are good supplements to the analyses presented. Below, I list several science and technical (mainly typos and grammatical) suggestions which should be incorporated into the final version of the manuscript. Line numbers refer to those in the revised manuscript. Once implemented, I believe the paper will be suitable for The Cryosphere and look forward to hopefully seeing it published in due course.

We appreciate the comments. The typos and grammatical suggestions are implemented and noted as 'done' in this document.

Scientific Comments

L45. Remove 'the whole or' (phase will never be a complete integer component of the wavelength'.

(L44) Done.

L53. 'Radiometric' isn't the correct word here since radiometry pertains to nearly all forms of remote sensing. Suggest 'optical and passive microwave satellite data' instead.

(L57) Done.

L71. I appreciate the authors response regarding this paragraph, although I'm afraid the final sentence still doesn't make much sense to me. If the Spergel et al. dataset exists, why didn't you use it? Perhaps it was not publicly available at the time of analysis? If so, this should be mentioned here, otherwise the sentence should be revised to improve clarity or removed.

It is true that it was not publicly available at the time of analysis. However, to avoid confusion, this statement has been removed.

L76. Following the author's responses to this sentence, I suggest stating explicitly here the fact that no data exist over Track 59 of Amery because this isn't available on the Copernicus Open Access Hub. (This isn't explicitly obvious from Table 1).

Changed to 'data from ascending track 59 before July 2017 are not available on the Copernicus Open Access Hub, as shown in Table 1'.

L79. Sentence beginning 'The final backscatter products'. Despite the author's responses to this sentence, I am still a little confused by this since the multi-looked cell size of the IW images on GEE are not 20x20 m (see https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S1_GRD; "This collection contains all of the GRD scenes. Each scene has one of 3 resolutions (10, 25 or 40 meters").

I understand in principle why the author's GRD images derived from SLC (SLC>GRD) might be gridded at this resolution, but not those from GEE. Was some element of post-download image

decimation/resampling carried out for consistency with the cell size of your SLC>GRD images? I suspect that more information must be added here for clarity.

According to the online documentation, the originally acquired resolution should be 10 m.

L84. *'Specific format'. What format? State here or reword sentence to remove this phrasing. It is '.raw' format, according to the documentation. Since it is not an important step, this sentence has been removed.*

L90. *In other words, TanDEM-X data is not available over Amery within DORIS at the time of processing. For concision, suggest rephrasing to more explicitly state that here.*

(L89) Changed to 'WGS84 geoid for Amery as it is the default DEM input of DORIS when TanDEM-X DEM of the same quality is not available at the time of processing.'

Fig. 1 caption. Change 'Landsat 8 RGB images' to 'Landsat 8 true colour images' since RGB is ambiguous (could refer either to the actual red-green-blue bands or some combination of non-visible bands visualised across the RGB guns). This should be changed universally throughout the manuscript.

This has been changed to 'true colour' throughout.

Fig 2. What does 'Write data in pixel interleaved 2b/2b complex short integer format' mean? Clarify in the caption or rephrase to avoid jargon.

It is '.raw' format to be processed and saved by DORIS.

'Compute the heights of the pixels in the radar coded system'. Does this refer to some sort of unused phase unwrapping or conversion of phase into a DEM? If so, suggest removing here.

According to the online documentation: 'In this step in principle the heights in the radar coded system are computed. However with the exact method, the geocoding can be done in the same step.' This could be in the same step with geocoding, therefore is removed.

L96. *Revise sentence for technical accuracy. Band 8 (panchromatic) has a native resolution of 15 m, not 30 m.*

Different resolutions have been specified.

L102. *For consistency with your SAR, optical and ERA5 data described elsewhere in the text, please state here the exact SSMIS product used and where you retrieved the data from.*

Citation to National Snow and Ice Data Center (NSIDC) has been added.

Fig. 6. Fig.6 is only referenced after Figs. 7/8 in the text, so these figures should be reordered/numbered in the captions and text to reflect this.

Please refer to the next comment.

L185. *This is the first time that Fig. 6 is mentioned in the text, so I'm a little confused as to why panels a and b (melt over Amery) are shown. I presume this is an omission in the discussion above on Amery Ice Shelf, so the authors should add some brief discussion on melt as a potential cause (or, more likely, not) of the coherence change somewhere in the section between Lines 146 and 153.*

(L152) Added 'During summer, low coherence occurs when the surface melts. This can be seen in Fig. 6a and Fig. 6b, where XPGR exceeds the melting threshold in Jan. 2017, and rises

towards the melting threshold in Jan. 2018.' This is prior to the reference to Fig.7 and Fig. 8, therefore the order of the figures is kept.

Technical Comments

L4. Remove 'Therefore,'.

Done.

L5. Remove 'C-band' (this is later specified (and better placed) on L8.

Done.

L35. Should read: 'To the intuitive representation'.

Done.

L41. Suggest rewriting sentence to read: 'InSAR processing uses pairs of images ...'.

Done.

L43. Remove 'considered'.

Done.

L73-92. I appreciate the revisions made to this paragraph for scientific/methodological clarity, although suggest that the ordering of the paragraphs should be reversed to improve clarity (i.e. change discussion of GRD and then SLC to SLC>GRD). This is because, as clarified by the authors in the text, the GRD products "are mainly used as supplementary backscatter intensity information when specific SLC tracks are not available". In this regard, it seems peculiar to mention how data gaps were filled using GRD before an explicit discussion of the main data sources first (SLC).

Please also see my scientific comments pertaining to these paragraphs.

The orders have been reversed.

L78. 'The GRD data are primarily acquired ...'.

Done.

L80. Change 'recalled' to 'termed sigma-nought (σ_0)'.

Done.

L84. Change 'and is illustrated' to 'whose processing chain is summarised in Fig. 2'.

Done.

L88. Change 'is applied in addition' to 'is also applied' or similar.

Done.

Fig. 1 caption. Typo 'Fig. Figure 3' and 'Fig. Figure 9'. Check for this universally throughout the manuscript.

Done.

L129. Change 'levels' to 'values'.

Done.

L131. Change 'drop' to 'decrease'.

Done.

L150. Change 'from' to 'of'. Then, suggest revising this and next sentence to read: '*...with large temporal variations which fluctuate between 0.2 and 0.6 between successive (6-day) image acquisitions. These sudden drops likely result from short-term, weather-induced changes in scattering properties, including snowfall events (cf. Fig. 5a)*'.

Done.

Fig. 3 caption. Does 'for all features presented' mean 'from all features indicated in Fig 1'? This isn't clear, so suggest revising to be more explicit.

Changed to 'from all features indicated in Fig 1'.

Fig. 4 caption. Should read: 'over a quarter year of observations. The transects as well as the 2D winter appearance of the feature and its surroundings are illustrated in the bottom panels'.

Done.

L154. Remove 'on the other hand, the coherence is lower as the' as this is implicit from the following text. Also, please consider citing Table 1 somewhere in this sentence.

Changed to 'On RBIS, the Sentinel-1 data are only available in a 12-day revisit cycle (as in Table 1),...'

L156. Remove 'in a 12 day revisit'. Suggest also changing 'Panel b) of Fig. 5' to 'Fig. 5b'. Also, suggest changing '... stronger precipitation' to '... a greater amount of total daily precipitation'.

Done.

L174. 'for only half'.

Done.

L180. Suggest changing 'Differently from ...' to 'In contrast to data acquired over Amery ice Shelf ...'.

Done.

Fig. 7 caption. Same comment regarding 'Landsat RGB images' as in Fig. 1 caption.

Done.

Fig. 8. For consistency with Fig. 7, suggest possibly arranging this panel so that sigma-nought is on top, coherence in middle, and true colour Landsat 8 imagery on bottom (i.e. a 3x2c layout as opposed to 2x3c).

Done. The caption is also changed accordingly.

Fig. 8 caption. Suggest changing last sentence to 'Two near-contemporaneous Landsat true colour images are also shown'. (See also my comments above on 'RGB' images).

Done.

L184. Please either refer to figure panels as 'Fig. X panel b)' or 'Fig Xb' and make this consistent throughout the manuscript.

Done.

L188. Change 'are sharp emerging' to 'sharply emerge'.

Done.

L189. Change 'strips' to 'curvilinear features' or similar.

Done.

L190-192. For concision/clarity, suggest rephrasing these sentences to: 'This feature is not visible in either σ_0 or optical imagery, highlighting the benefit of InSAR-based coherence for the detection and monitoring of sub-surface lake networks'.

Done.

L195. Change 'shows' to 'is associated with'.

Done.

L199. Suggest beginning sentence 'That both fringe ...'.

Done.

L206. I think 'forming a concentric pattern of deformation associated with a series of dense, closely spaced fringes' would be better than 'a whirl-like feature'.

Done.

L210. 'This would ...'. What would? Suggest rephrasing to: 'This hypothesis is consistent with earlier observations, including the rebound effects described by Banwell et al. (2013)' to be more explicit.

Done.

L213-224. This paragraph is rather complex in that it tries to discuss backscatter, coherence and phase all at the same time and then, confusingly, introduces phase on line 222 before talking about the advantages of phase observations over backscatter/intensity.

For clarity, I would encourage the authors to first discuss the backscatter and how this compares to the coherence imagery, and then talk about phase (and its advantages in reducing ambiguities) afterwards. Restructuring the paragraph in this way would be more consistent with the broader layout of the results/discussion, which I think will help the readership.

The whole paragraph has been re-written.

L222. Incorrect grammar/sentence tense. Should read: 'Interferometric analyses show similar results (Fig. 10)' (although see comment above – this sentence will likely be removed).

This sentence has been removed.

Fig. 9 caption. Try to avoid beginning sentences with mathematical symbols or other (uncommonly used) abbreviations. Should read: 'Sigma-nought (σ_0) and interferograms ...". Same comment regarding Fig. 10.

Done.

L231. '*... based only on ...*'.

(L238) Done.

L234. '*...may not therefore be...*'.

(L241) Done.

L238. '*...variations can indicate ...*'.

(L245) Done.

L239. '*...may consequently be due to ...*'.

(L246) Done.

L245. *Could this be better worded for clarity, as I'm not sure exactly what this refers to? (to me, disc and rings are perfectly circular shapes ...). The authors previously used 'polygonal features' in is context, so suggest the same or similar term be used here for consistency.*

(L252) The disc shape refers to the whole lake, while the ring shape refers to only the edge. This sentence has been changed to 'The change from complete polygonal low coherence patterns to partly high coherence...'

L255. *Suggest replacing 'revealed' with 'imaged' or 'constrained' or similar.*

(L263) Replaced with 'imaged'.

L256. *Suggest rewriting as: '... is shown clearly in Fig. 9, where the closely spaced fringes shown could be used to estimate the presence of an uplift event due to drainage'.*

Note: I still think a rough estimate of uplift would be meaningful/interesting to the readership here, which you might also include in the appropriate section of the results. I accept the author's concerns that this would be a relative (LOS) displacement only, and that a lack of in-situ observations exist to validate this phenomenon, but as long as these caveats are also explicitly mentioned I think that this would be acceptable.

Done. Added 'By counting the fringes, the feature consists of approximately 7 fringes, each measuring 2.8 cm in the line-of-sight. Assuming a vertical movement, this corresponds to an uplift of approximately 24 cm (taking into account an incidence angle of approximately 35°). However, this amount of uplift is only an approximation of a displacement relative to ice flow and tidal component, and needs in situ observations to validate.' to L213.

L260. '*e.g. strong snowfall events, as shown in Fig. 5*'.

(L269) Done.

L264. *Change 'done' (colloquial) to 'performed', 'carried out' or similar.*

(L273) Changed to 'performed'.

L267. *For clarity, suggest editing to read: '... additional processing will likely be needed to cancel out, for example, the effects of ice-shelf flow (Mohajerani et al., 2021) ...'.*

(L276) Done.

L276. Grammar. Suggest rephrasing to: *'Four Antarctic ice shelf regions subject to intense summertime melt have been analysed using Sentinel-1A/B C-band SAR imagery...'*

(L285) Done.

L283. *'circumstances'*.

(L292) Done.

Response to Editor

We also would like to appreciate Dr. Chris Derksen for editing this manuscript.