Response to Referee 2 on tc-2021-169

Thank you for reviewing and commenting the manuscript. Please find the item-by-item reply below, with the original comments in *italics* and the responses in blue.

General comments: This paper evaluated the beneficial of combining SAR amplitude, InSAR coherence and phase information for meltwater lake dynamics. The topic fits well with The Cryosphere journal and it provides useful information for investigation for lake dynamics in Antarctic environment. The selected cases over Amery and Roi Bauouin ice shelves (RBIS) shows that SAR amplitude, InSAR coherence and phase are complimentary for lake dynamics monitoring. However, I think the presented examples may oversimplify the interpretation of SAR amplitude, coherence and phase for monitoring meltwater lake dynamics, as we know other factors, other than seasonal melting-refreeze process, such as weather event (snow, rainfall, et,al) and sensor acquisition geometry (descending/ascending) could also affect amplitude/coherence/phase variation. There are also some other issues with this paper, such as convincing evidence about the lake status in the analysis, and incomplete/confusing data information that were used in the study.

We would like to thank Referee 2 for the positive comments on the potential. We agree with the arguments that other factors such as changes in snow properties and sensor effects also may impact the signals. This was in fact mentioned already in the manusript, but it was perhaps not given the proper weight. In the revised version, we will stress the role of these other interpretations more clearly to avoid the impression of oversimplification.

Specific comments

1) Instead of just few selected data, please provide a complete time series amplitude, coherence and phase analysis for the cases in Fig 4 & Fig 5. I think this would still show the benefits of different information (amplitude, coherence and phase), but it would provide a more objective sense/perspective for reader to understand potential drawbacks of each different information. Incomplete data also make some of the statements confusing in the paper. For example, Line 155-157, it talked about amplitude/coherence for summer melting, but there are no SAR data shown in the Fig 4.

Starting from lines 155-157, we perhaps caused confusion by mentioning the melt of the ice. The lines refer to the background blue ice area, rather than the lakes. And the blue ice features are shown in the second panel at the bottom of Fig. 4 (RGB bands of Landsat image). We will try to clarify it in the revised manuscript.

As for the complete time series, it has 60 days of acquisition, and showing all the NRCS, coherence and phase images will result in 3*60=180 images. This is not ideal to show in one figure, but if it is required and if the editor agrees, we could add it as Supplementary Material.

2) Please provide evidence when refer to melting/refreeze/frozen status of the lake to make your statement convincing. For example, the authors explained the decorrelation in Jan 2017 data is due to melting (Line 195-196) in Fig 7. However, in this same figure, we see the Jan 2018 shows very good coherence and phase pattern. I would assume the area would be in similar freeze/melt status at approximate same time of different years. I am not sure whether

the low coherence in Jan 2017 is due to melting or maybe other weather events. I think it would be helpful to collect some other information, such as temperature information from other sources, to support your statement. For all other data analysis, if it's possible to collect some external information such as temperature or optical imagery, I would suggest doing so that it's more convincing when you state its under melt or refreeze or frozen status.

Based on previous studies, we are sure that it is melting, due to the backscatter drop that would also be identified as melting in a typical melt-detection algorithm. We appreciate the referee's suggestion in using other external data sources. It is difficult, however, to acquire completely concurrent Landsat images due to the cloud cover. We will therefore include ERA-5 data or similar climate products in the revised manuscript to show it more clearly.

3) Incomplete data information. For the time series of mean and standard deviation over selected polygons mentioned in Fig 2, How many SAR data are used for this calculation and what are their acquisition times? are the mean and std for all the polygons shown in Fig 1? It might be helpful to provide complete data list in text or supplement. Are the coherence data for Amery all 12-days product? It would be not meaning to mix 6-days or 12 days data together to analyze lake-related information, as temporal difference would change that a lot.
Please show the outline of the sentinel-1 data in the last panel of Fig 1. What is the data coverage used in this study? Table 1 shows RBIS SLC data is from 2017/7/25—2018/4/15, however, in fig 2, the data coverage for RBIS is from 2017/1-2018/1, it is so confusing. Please provide accurate info for data you used. Also, the GRD and SLC time coverage are different as shown in fig 2, not sure how does this happen. I would assume you need to analyze amplitude/coherence/phase comparison for all data.

We are sorry to hear that this information seems incomplete. The line/fill plot in Fig.2 with the lakes' means and standard deviations refers to all the polygons shown in Fig. 1. Analogously, the snow and ice polygons plotted in Fig. 2 are the ones already highlighted in Fig. 1. This information is briefly contained in the caption of Fig. 2, but perhaps the amount of data (number of lakes and snow/ice samples) is not explicit. We will detail the caption of Fig. 2 further in the revised manuscript. It is instead true that the Amery series have mixed 6-day and 12-days coherence. More specifically, the first pair (04-Jan-2017 -> 16-Jan-2017) is separated by 12 days, whereas the rest of the Amery acquisitions is characterized by 6-days repeat. We will make sure to clarify this in Table 1. In conclusion, although we agree with the reviewer that the mixing 6 days and 12 days coherences should be done with caution, we believe that in the case of Amery, the impact of this temporal heterogeneity is negligible. Also, in interpreting the coherence differences between Amery and RBIS, we highlighted the fact that the latter have lower values also due to the longer (12 days) interval (lines 144-145).

The second part of the comment is not clear to us. Regarding the timespan of the plots in Fig. 2 for the two different areas, we believe that they are coherent with the dates specified in Table 1. The first and third plot refer the Amery, whereas the second and the forth refer to RBIS.

4) Are there any different characteristics in amplitude/coherence/phase between supraglacial and englacial lake?

Sentinel-1 has only limited penetration depth of several meters, so only shallow englacial lakes can be detected. However, our time series of Fig. 7 might actually be some sort of englacial lake (by developing a frozen lid). And we will discuss this aspect better in the discussion.

Technical correction:
Line 113, 'the results', please be more specific.

It refers to Fig. 2. We will clarify this in the revised version.

Fig 2. Please provide complete legends for subplots 2-4. Fig caption are not complete. It only takes about the time series, but not the specific amery a, b, d and RBIS examples.

The examples are labelled by the legend. We will try to be more complete and the caption will be extended.