

## ***Interactive comment on “Brief Communication: Ice Sheet Elevation Measurements from the Sentinel-3A / 3B Tandem Phase” by Malcolm McMillan et al.***

**Malcolm McMillan et al.**

m.mcmillan@lancaster.ac.uk

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We thank the reviewer for the time they have dedicated to reviewing our manuscript, and are grateful for their comments, which we believe have substantially improved the manuscript. We address each of the reviewer’s comments in turn; reviewer’s comments are prefixed by an asterisk.

\* This brief communication (BC) provides an overview of what’s gained by incorporating a tandem phase to the commissioning of new radar altimeters. As shown in the BC one could only have wished that this concept had been performed in the past during the commissioning of ERS-2, ENVISAT, and AltiKa. The BC limits the space available

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for more in-depth analysis of the data gathered in the tandem phase. However, after reading the manuscript I'm left with a feeling of wanting more. Here, a more classical cross-over analysis would have been obvious and a cross-over analysis of the two instruments during the tandem-phase might have given insights to the instrument degradation of S3A. However, I fully acknowledge that only the "added information" of the unique tandem phase is the scope of this BC. With this in mind, I'm only left with minor comments to the BC.

As noted by the reviewer, we have chosen not to include a classical cross-over analysis here, because we wanted to focus on the specific novel aspects that could only be achieved thanks to the tandem phase. However, in our revised manuscript we have added considerable extra analysis and novel results that we hope will be of interest to Reviewer 2, and will satisfy their thirst to know more, within the scope of a Brief Communication.

Minor comments:

\* I11: Add Copernicus in front of Sentinel

'Copernicus' added as requested.

\* I12: remove "each of"

'each of' removed as requested.

\* I15: "co-located measurements to be acquired" to "co-located measurements of surface elevation, to be acquired"

Text modified as requested.

\* I19: Shepherd 2019 should be 2020.

This reference is, to our knowledge, correct as the paper was published on 16 May 2019: <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019GL082182>.

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\* L24: add a reference to a technical paper about the program/Sentinel-3

Reference added as requested.

\* L37: how many cycles?

Text added as requested: “three full cycles of tandem delay-Doppler measurements”.

\* L47: Suggest removing the section and incorporate the information in the intro.

We would prefer to keep this as a distinct section as we believe it is clearer for the reader.

\* L49: Baseline 2.27? Please elaborate on this baseline numbering, how does this compare to Baseline 004, which is available at the sci-hub?

Baseline 2.27 relates the specific product baseline, which is part of a Baseline Collection 00X, e.g. ‘004’ on sci-hub. In this case we used the Product Baseline 2.27, which is part of Baseline Collection 003, and we have clarified this point in the text.

\* L51: Spirit, please add the geographical information.

Geographical coordinates added as requested.

\* L53-55: Please use the right references for these two data set as posted on NSIDC. I know the references are limited, but the big effort of collecting airborne data should be acknowledged.

Apologies for this oversight – we have now added the correct references.

\* L69: "complex topo..." should do. What is non-linear?

Text modified as requested. We had meant that elevation did not vary linearly with horizontal distance, but we agree that this wording was not clear and therefore unnecessary.

\* L71-72: coherent waveforms: Is this analyzed by eye or do you have a measure?

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It was the former in the original manuscript. However, please note that we have now undertaken a quantitative assessment, and also expanded it to the ice sheet scale – see our response to Reviewer 1’s comments.

\* L73: “future possibilities”: I can see how this is done for CS2 with the phase information, but how would you go about this here. Could you give some in-sights?

As requested, we have elaborated on this point.

\* L79: “central part of. . .” Could you be more specific? I see the figure has coordinates, but what is the projection? The same is the case for Figures 1 and 3.

As requested, we have added projection information to the captions of all figures. The projection used is the WGS 84 Antarctic Polar Stereographic projection with 0E central meridian and a 71S Latitude of true origin.

\* L85: the number of significant digits should be the same

According to our understanding of significant figures, then the numbers 0.094 and 0.10 do have the same number of significant figures; i.e. 2. However, on reflection we think it would be better to include the same number of decimal places, and so we have updated accordingly.

\* L94: insignificant, I guess you used the same tests as above?

Yes – text added to clarify this point.

\* L99: “recent” the first

Text modified as suggested.

\* L104: What about the satellite degradation? S3A has now been in orbit 2 years more than S3B, is this what is seen in Figure 1 with a possibly noisier S3A waveform?

For measurements of elevation, and elevation change, we believe that our analysis shows that satellite degradation over 2-years has had no significant impact upon the

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elevation measurements themselves. In a further more technical study, it would be possible to look at whether there is any change in the noise statistics of the waveforms, both the multi-looked 20 Hz waveforms and also the lower level echoes. This would, however, require a far more detailed assessment of the lower level data than the 20 Hz comparison presented here. As such, we believe that this would be a distinct study, separate from this short communication.

\* L105: “indicates” - This should be stated clearly that we would need similar observations to be made when S3C and S3D are entering service.

As suggested, we have modified the text so that this conclusion is more clearly stated.

\* All figures are missing information about the projection and geographical coordinates.

As requested, we have added projection information to the captions of all figures. The projection used is the WGS 84 Antarctic Polar Stereographic projection with 0E central meridian and a 71S Latitude of true origin.

\* Figure 1: For parts of the waveforms S3A looks noisier, is there a way to judge if this is the case? Add more information to section 3 about the inter-comparison of the waveforms.

As requested, we have now added considerably more detail relating to the inter-comparison of waveforms – please see our responses to Reviewer 1 and also the above comment relating to Line 104. In this study, we have chosen to focus on the overall correlation between the waveforms, because to perform an analysis of the noise content specifically would be a substantial technical piece of work, which is beyond the scope of this brief communication. For example, it would entail derivation, testing and analysis of methods that were able to separate instrument noise from topographic artefacts (i.e. real geophysical signals) within the waveform. We believe that this is well beyond the scope of this brief communication, and is a topic that should be considered as part of a future study.

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\* Figure 3: suggests replacing a and b with an along-flight-trace profile.

We would prefer to keep the figure as is, because (1) it maintains consistency with McMillan et al., 2019, and (2) it more clearly shows the topographic configuration of the surface, via the MOA greyscale background image.

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Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-223>, 2020.

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