

Review of Zhang et al. (2021)

General comments:

This study describes the methods used to produce a new dataset of surface elevation changes of the Greenland Ice Sheet from satellite radar altimetry observations acquired by ERS-1, ERS-2, Envisat and CryoSat-2 spanning the period 1991 to 2020 and features some illustrations of this dataset over specific glaciers of the Greenland Ice Sheet. The main novelty in the methods described here is the use of EOF modes to fill in the monthly grids of surface elevation change.

I have some important general comments and questions that need to be addressed before I can recommend this manuscript for publication:

- Is it a reasonable assumption to assume that 'spatial patterns of GrIS SECs are stationary in time' (L153) in your EOF reconstruction? The pattern of SECs has evolved from the 1990s to the 2003-2020 period. The authors themselves show this in Figure 4 where we can see the spread of thinning further inland between panels a (1991-2000) and c (2011-2020). How robust is this assumption?
- The SECs dataset comes with an uncertainty estimation, which is great but I am not convinced by the uncertainty assessment made here. I understand that using the MAD is straightforward but I wonder if it is a good measure of the uncertainty of the measurement. While I recognise that it is difficult to formally account for the different sources of uncertainty in the altimetry SECs measurements, some useful information/discussion could be added regarding the uncertainty assessment – for instance a discussion of which step in your processing contributes to larger uncertainties (is it the inter-mission calibration, the formulation-n of the plane-fit model...?)
- I would rename Section 4 'Comparison to Independent Datasets' as this section is not really an uncertainty assessment but more a validation/comparison analysis to the ATM and CCI datasets. I suggest to move the first subsection 'Error sources' at the end of this section and rename it 'Limitations of the dataset' or something along those lines.
- In the 'Results' section on the analysis surface elevation anomaly time-series, the authors look at decadal trends in SECs over specific glaciers which highlight the long record that they have produced. This is a good illustration of the potential use of the dataset and it would be good to also feature an illustration of the ability of the dataset to look at seasonal changes in elevation change to highlight the high temporal resolution of their dataset, or at least to discuss this in the text.
- Do you see any step change in the SEC time-series following the 2012 extreme melt event in the interior of the ice sheet? Could you comment on whether this artefact is present in your time-series or if your processing scheme is able to correct for this effectively?
- It is straightforward to download the data from the link provided but there are quite a lot of typos in the metadata of the NetCDF file: 'latitudt', 'longitudt' or for instance the description of the basins variable states: 'Antarctic_Drainage_System_Boundaries_and_Masks' when it should be 'Greenland_Drainage_System_Boundaries_and_Masks'.

I made some specific comments and suggestions below, which I hope will help improve this paper.

Specific comments:

L8: 'for study of ice sheet variation and its response to climate change', please reformulate

L26: You also need a density model for the snow and firn layer in addition to a model of the distribution of the ice layers within the firn column to convert volume change to mass change. Please clarify this sentence.

L28: Please be more specific in this sentence, a long-term time series of EC is essential to assess the impact of climate change on the ice sheets rather than 'to assess climate change directly'.

L56: I recall that the deconvolution method from Slater et al (2019) does provide time-variable penetration depth over the interior of the Greenland Ice Sheet.

L57-58: 'a more reasonable approach' than? I would argue that the reason to combine data from several radar altimetry missions is that it is the only way to get a long record of surface elevation changes. I would remove this sentence, as it doesn't link with what was said in the paragraph.

L59: By irregular, do you mean that the satellite tracks deviate from the ground-tracks? I think you need to be a bit more specific here as this sentence could be misread. ERS-1/2 and ENVISAT have a repeat cycle and CryoSat-2 a drifting orbit but all missions have regular a ground track pattern.

L64: 'for to unobserved grid cells'

L85: Specify how similar the sensors are (for instance they all use Ku-band etc). You could also mention Sentinel-3 here. Could your processing scheme be applied to Sentinel-3 data as well?

L93: typo 'SARIn'

L171-172: How do you estimate the seasonal signals here? Do you use the terms from the plane fit model or do you estimate the seasonal components using a time-series decomposition technique?

L175: Can you add the average proportion of the monthly grid that has be filled in using the EOF modes for each mission? Data are rather sparse during the ERS-1/2 periods compared to the CryoSat-2 period when only small gaps between tracks occur. It would be useful to add a sentence in the text to reflect this.

L204: Did you look at trends in surface mass balance to support this claim?

L217: Are there limitations of your dataset to look at SECs over some small glaciers? Is there an optimal area size for glaciers for which your dataset would be the most useful? Is your dataset reliable close to the termini of glaciers where altimetry measurements are usually sparse and the slope is high?

L227: typo 'Greenland Ice Stream'

L235-236: Not all fluctuations in SECs are caused by climate change, in case of short-term fluctuations it is hard to distinguish between natural climate variability and climate change

L292: Here the advantage is to use radar altimetry instead of laser altimetry to look at elevation changes induced by SMB processes. I would add in the sentence 'by combining data from multiple radar altimetry missions'

L553: typo 'left-hand maps'

Fig 9: Please clarify the caption, it's unclear from the caption what is shown on Figure 9b. Reading the caption alone, it looks like maps a and b are showing the same thing. Also, what do you by the same epochs for map c?

Table 2: What do you mean by 'periods across the Envisat and CryoSat-2 connections?' I would maybe say 'overlap' rather than 'connections'.