Author's response

We would like to thank both reviewers once again for their very detailed and supportive feedback on our manuscript. The comments and suggestions have greatly improved our manuscript and helped us a lot to shorten and clarify it. Below we provide a point-by-point response to each comment, sometimes referring to our responses to the review giving prior to the revision. Reviewers' comments are in italics.

REVIEW 1

1 Major comments

1.1 *Overall this paper is very dense/wordy, it reads more like a report than a scientific paper. Some sentences and paragraphs seem to just be added as filling without a clear purpose. I suggest heavily cutting the text, especially in the introduction and data section. See some specific suggestions further down.*
- We have significantly shortened the manuscript, in particular the introduction and the data section. We have reduced the main text length from 741 lines to 581 lines.
- We have slightly modified our methods for ease of presentation and explanation, as previously described in the responses to the reviews. We now use the altimetric variations as input to our regression approach. We have therefore restructured the method sections as follows:
    - 3.1 Basic approach
    - 3.2 Principal component analysis of modelled firn thickness variation
    - 3.3 Regression approach
    - 3.4 Different versions of adjusted firn thickness variations
    - 3.5 Assessment methods
- Further, we have reduced the number of figures or subfigures. We have removed Fig. 2, 5a and 5f, 6, 9b, 10a, 11a-c, 12a-c and 16b.

1.2 *There are a lot of sentences where you use a full stop rather than a comma.*
- We have rephrased or combined the relevant sentences.

1.3 *Furthermore, there are a lot of grammar errors, like Line 94/95 "Nevertheless, discrepancies still remain. (See Section 2.3 for further details on comparisons between altimetry and firn models.)" It is not grammatically correct to start a new sentence with a paraphrase. All these things are disrupting the reading flow. This paper could really benefit from a proofread! See some specific suggestions further down.*
- We have removed the parentheses and rephrased the sentences if necessary.

1.4 *There are a lot of inconsistencies in the figures, especially with the colour bars (spatialplots). It seems random if the colour bars have a min or max arrow extension, or both arrow extensions. These colour bar inconsistencies are seen throughout the paper. Also, in Figure S13 red is negative and blue is positive, just below in Figure S14 purple/blue is negative and brown/red is positive. Please go through them all and double-check if all the colour bars are correct.*
- As mentioned in the response to the review, we have added the following sentence to each figure that has a mixture of no arrow extensions and arrow extensions: "Colour bar arrows indicate that the value range exceeds the limits of the colour scale."
- We have changed the Fig. S13 colour bar accordingly.

1.5 *Snow and firn are mentioned many times but the terms are not well defined here. The manuscript could benefit from a clear distinction between snow and firn. Further, sometimes it says snow/firn layers in plural*

and sometimes the layer is singular, and firn pack is also used. It seems like the terms are used interchangeably, please make sure to be consistent, as they have different meanings.

- We have clarified the terms in the introduction when explaining surface mass balance (SMB): "It refers to processes occurring on the surface of the ice sheet in the snow and firn layer. Snow refers to the seasonal snow cover, i.e. it is less than a year old. Firn refers to multiyear snow and is defined as the transition from snow to glacier ice (van den Broeke, 2008). In the following, we refer to both snow and firn by the term firn layer."

2 Minor comments

2.1 *In section 2.4 it seems like you start to present and discuss results (Fig. 1 and 2), this feels out of place in the method sections.*

- We have removed Section 2.4.

2.2 *In Section 2.1 you refer to the two altimetry datasets as "TUD altimetry" and "JPL altimetry" in lines 124-126. But in the section, you also call them "TUD" and "JPL", or "TUD product" and "JPL product", or "Schröder et al. (2019a)" and "Nilsson et al. (2022)". When you make a definition in the beginningyou should consistently use that. Likewise in section 2.2, you refer to the two firn models as IMAU firn model and GSFC firn model, within the same section you call them "IMAU", "IMAU model", "GSFC", and "GSFC model". When you make a definition in the beginning you should consistently use that.*

- We no longer use the abbreviations TUD, TUD altimetry, JPL, JPL altimetry, IMAU, IMAU model, GSFC and GSFC model. Instead, we now use only the references of the data sets.

2.3 *In the caption of Figure 2, you write "Color" which is American English other places you write "metre" which is British English. Please choose one way and be consistent.*

- We have changed it to "colour" as we are using British English.

3 Specific comments

L21: The references " (Horwath et al., 2022; IPCC, 2021)" are here in alphabetical order, the rest of the references are in timely order oldest first.

- We have changed this to: "Ice-mass loss from Antarctica contributed ~6 % to this rise (Horwath et al., 2022), and is likely to continue (IPCC, 2021)."

L33: "in the snow and firn layer" This reads like there is no difference between snow and firn

- Please see our answer in 1.5.

L53: Suggest change "They are forced" to "They can be forced", because not all RCMs use reanalysis data.

- We have combined this sentence with the previous one as follows: "When the main goal of RCMs is to realistically simulate the ice sheet weather, as is the case here, they are forced by atmospheric reanalysis products and thoroughly evaluated against hundreds of in situ observations of SMB (van Wessem et al., 2018; Agosta et al., 2019)."

L58: "However, spatial variations in SMB show a poorer agreement. On a basin scale, the largest…" remove the full stop after "agreement" use a comma instead as the following sentence is a continuation.

- We have greatly shortened this and the following sentences: "However, the spatial patterns of the different SMB estimates differ substantially on a regional and local scale."

L81: "They" who?

- We have replaced "They" with "These measurements".

L87: Here you have snow/firn layers in plural in L33 the layer is singular.
- According to our definition above (see 1.5), we have changed this to: „(…) while radar signals penetrate into the upper firn layer." Here, and everywhere else we will use the singular."

L118-119: "For the first time, the entire spatial information present in both the altimetry products and modelling outputs, together with the high (monthly) temporal resolution of gridded altimetry products, is jointly exploited." This is a convoluted sentence, e.g "altimetry products" is mentioned twice, please rewrite.
- We have rephrased: "For the first time, the full spatial and temporal information present in the altimetry products is exploited together with the modelling results."

L131-132: Suggest changing the full stop to a comma between "differs. Thus,"
- We have rephrased and combined both sentences: "While the orbit configurations of the missions entail different limits of coverage close to the poles, all mentioned missions cover at least up to 81.5° S."

L177-178: In SMB components you are missing refreeze/runoff
- The IMAU firn model is not forced with all SMB components, but with the fluxes and boundary conditions at the top of the firn layer. Refreezing is a process happening in the firn itself, so this is calculated within the IMAU-FDM model, same as runoff.
- We have revised the description of the GSFC firn model und removed "runoff" as a forcing parameter (L181 of the submitted version). The MERRA-2 land ice runoff flux is provided at monthly resolution (Medley et al., 2022). Medley et al. (2022) use their own degree-day model to generate meltwater fluxes for the input to the firn model. Thus, runoff is also calculated in the model, provided as an output and compared with the MERRA-2 runoff.

L179: "dynamically downscaled with RACMO2.3p2" does that mean that you have run the RACMO model?
- As this is not the case, we have rephrased: "The firn model from Veldhuijsen et al. (2023) is forced with three-hourly fields of surface temperature, 10m wind speed and SMB components (snowfall, rainfall, sublimation, snowdrift erosion, snowmelt) from RACMO2.3p2 (van Wessem et al., 2018). RACMO2.3p2 uses a spatial resolution of 27km x 27km and is forced by the ERA5 atmospheric reanalysis data (Hersbach et al., 2020)."

L262: Replace full stop after regression with comma
- We have rephrased these sentences: "The stochastic model of our regression in Eq. 1 prescribes a different weighting of observations from two time periods. As results from the older altimetry missions generally have a higher noise level (Schröder et al., 2019a; Nilsson et al., 2022), hv^A after 2003 are weighted by 1, while hv^A before 2003 are given a different (usually lower) weight, which is defined, individually for every grid point, by the ratio of the noise variance of hv195 A before and after 2003."

L306: Suggest remove " ('R squared')"
- Instead of removing "R squared", we have removed "the coefficient of determination" and we now refer to R^2 as R squared throughout.

L328: Shouldn't you also refer to fvE1?
- We have added: "Note, that we do not introduce fv^{E1} as this would correspond to fv^M."

L330: "These alternative variations are called scaled firn thickness variations. We refer to them by fvE2", replace full stop with a comma.

- We have rephrased: "We refer to the results as scaled firn thickness variations, fv^{E2}."

L332: "These alternative variations are called modified adjusted firn thickness variations. We refer to them by fvE3", replace full stop with a comma.
- We have rephrased: "We refer to the result as modified adjusted firn thickness variations, fv^{E3}."

L345-355: Please add references for the Kolmogorov-Smirnov test
- We have added Massey (1951), Miller (1956) and Marsaglia et al. (2003).

L595: "also high" please put a number on that.
- We have rephrased this sentence: "In case of basin 8, models and altimetry disagree (Fig. S17e–h), as well as the different versions of fv^{M} (Fig. S16d) and the different versions of fv^{A} (Fig. S15i–l). The latter is discussed in Sect. 5.4." We have chosen this qualitative way of describing the disagreement as the absolute numbers may not be essential. This style fits with the description of basin 4 at the beginning of the paragraph.

L610: What is meant by " measurement noise"?
- We have rephrased: "Noise in the altimetry measurements might explain (…)"

L731: Changes the full stop between noted and By to a comma, as it is the same sentence
- Here and in L726, we have deleted "one caveat should be noted" and we have combined "However" with the following sentence.

4 Figures
Fig3 caption: you write ". Drainage basins of the EAIS and WAIS used in this study (thick black lines) following Rignot et al. (2011a, b)." but then in L298-299 you talk about regions and multiple Rignot basins forming one basin. Please clarify when you talk about Rignot basins, "your" basins or other regions
- In Fig. 3, we have clarified: "Drainage basins of the EAIS and WAIS used in this study (thick black lines), slightly modified from the definition of Rignot et al. (2011a, b)."
- In the following, we have changed "regions" to "basins".

Fig3: I suggest that you put all the areas/regions which you mention in the text
- We have included the region names in Fig. 3.

Fig10: The left colour bar has only max extend while the right has both min and max extend. Also are there even Coefficients of determination for the regression that are negative, like the min extend suggests?
- Please see our previous response. Further, Sect. 4.2.1 illustrates the derivation of adjusted firn thickness variations for a selected grid point. There, we have rephrased L408-409: "Because of the different weighting of hv^{A} before and after 2003 (Sect. 3.3), R^2_{A} can indeed be negative and distinguishing the two periods is reasonable."

Fig11: Shouldn't there be a min extension on the colourbar?
- In the text (L486-487 of the submitted version) we have rephrased and explained: "The employed software to estimate κ (Bos et al., 2012) has -3 as its minimum output value."

Fig A1: Shouldn't there be a min extension on the colour bar?
- Please see also our previous response. As it was just the labelling in the wrong place, we have corrected that.

The following comments refer to sentences or parts of the manuscript that have been deleted and are no longer included in the revised version. Therefore, these comments are no longer addressed point by point. Explanations and replies to specific comments and questions have been provided in the response to the review.

- *L44: "statistically significant trends in the Antarctic (surface) mass balance" this statement needs a reference.*
- *L52-53: "Earth system models have recently caught up in this regard (Lenaerts et al., 2019)". Is this sentences relevant? ESMs are not mentioned anymore.*
- *L54: "data from 1979 onwards" I guess you refer to ERA-interim put we have ERA5 now starting in 1950*
- *L87: "If elevation changes due to changing ice flow can either be neglected or subtracted…" Please argue where or when they can be neglected.*
- *L94: "Nevertheless, discrepancies still remain. (See Section 2.3 for further details on comparisons between altimetry and firn models.)" Incorrect grammar, suggest rewriting to: Nevertheless, discrepancies between altimetry and firn models still remain and are discussed.*
- *L98-99: "The reason likely lies in errors in the involved altimetry and modelling results" Is that not always the case? either the errors are from the altimetry or the model.*
- *L99: "Therefore" what?*
- *L99: What is meant by a "Steady-state" density model?*
- *L140: Here you write firn pack and firn layer as earlier.*
- *L198: Suggest to delete this line, it sounds like a rapport.*
- *L199: Again "TUD, JPL"*
- *L201: Missing reference to ERA-Interim.*
- *L204: Define the sign of rates, is a positive rate making the surface go up?*
- *L206: Remove "section 2.2"*
- *L207:"more positive" does that mean thicker firn or a faster thickness rate?*
- *L208: "less negative" slower thickness rate, or slower thinning rate?*
- *L210: Do you mean the average ice sheet-wide seasonal amplitude in firn thickness? Or are you talking about ice sheet seasonal amplitude?*
- *L211-213: It is unclear what these numbers are, Are they seasonal differences in firn thickness? Are they integrated over the entire ground AIS?*
- *L215: Which basin definition?*
- *L215: Remove " In this section" it sounds like a rapport.*
- *L219: ". (For the JPL altimetry, h A2, and the GSFC firn model, f Mb, similar time series are shown in Fig. S1.)" using the parentheses is incorrect grammar.*
- *L220: "Agreement between hA1 and fMa is generally good on interannual scales. Differences appear in the long-term trends." these are two very short sentences, I suggest removing the full stop.*
- *L225: Here you say the entire period is 1993-2017, does it not start in 1992?*
- *L230: put s on "model" since you are referring to both models.*
- *L230-231: Using the parentheses is incorrect grammar.*
- *L247: ". It is explained in Section 3.1.1" maybe change to ", this is explained in Section 3.1.1"*
- *Fig9 caption: Replace full stop with and "Histograms. Vertical"*

All the following comments will be revised as suggested.

- *L57-63: This could be written much shorter, it is not a review in Mottram et al 2021.*
- *L64-70: Again this could be written much shorter, it is not a review in Verjans et al 2021. I do not think all the numbers are necessary*

- *L71-79: In my opinion, this paragraph could be removed, as gravimetric mass balance is not the topic of this paper.*
- *L80: Remove "By contrast"*
- *L83: Change "utilise(d)" to utilise*
- *L84: Change "(ICESat-2)" to (ICESat), as your time period ends in 2017 and ICESat-2 was first launched in 2018.*
- *L86: "laser signals are reflected at or near the ice sheet surface". I think you mean "laser signals are reflected at or near the surface".*
- *L102: I suggest merging sections 1.2 and 1.3 and removing the text about gravimetry in Sec. 1.3*
- *L104: Remove "(Section 1.2)"*
- *L111: I suggest also merging sections 1.2, and 1,4 and then writing the "purpose part" in the last paragraph in Sec. 1.2.*
- *L113: Remove "(Section 1.1)"*
- *L162-163: Why mention the Shepherd et al 2019 data when you are not using it? I suggest removing these lines.*
- *L172-173: you write "In accordance with the altimetry data, we involve firn thickness changes from the grounded AIS excluding the Antarctic Peninsula and the period May 1992 to December 2017" This sentence says that you exclude the AP and the period 1992-2017, it should likely say that you use the period 1992-2017*
- *L182: "firn layer" singular*
- *L192: " Medley et al. (2022a) built a new model" should it not say parameterisation instead of model?*
- *L284-286: "Comprehensive and general references…." this feels like it is a bit misplaced perhaps to put in the references after "respectively"*
- *L305: Suggest to merge section 3.1.1 and 3.1.2 as sec. 3.1.2 is very short.*
- *L311: Label eq 5a er 6 instead. It is a bit strange to have Eq 5 followed by eq 5a*
- *L360-361: ". (For example, power-law with κ = −1 and κ = −2 represents flicker and random walk noise, respectively.)" using the parentheses is incorrect grammar*
- *L365-366: ". (Note that the residuals may additionally contain signals related to variations in ice flow dynamics or subglacial hydrology.)" using the parentheses is incorrect grammar*
- *L398: "standard deviation" => std, the abbreviation is already introduced.*
- *L402:"(In the case of data gaps in the altimetry time series, this equality holds approximately.)."*
- *L409: Remove "(Section 3.1)"*
- *L431: "(The rms of all versions of fvA and fvM is illustrated in Fig. S17a–d and Fig. S18a, b, respectively.)"*
- *L441:"(Corresponding rms maps of differences are displayed in Fig. S17–S19)."*
- *L448: Section 4.2.4, you already have a section with the same title, this is confusing.*
- *L456-457: "(Fig S20 and Fig. S21 further shows maps of the residuals rms and of R2 for different versions of regression and both time periods. Table S1 lists basin averages of R2 for the period before 2003.)*
- *L472: "(Basin-mean time series of all regression results and versions are presented in Fig. S22–S24.)"*
- *L478-479: "(For the larger subset of selected grid points, Fig. S25 and S26 display the psd of the regression results from A1a and A2a, respectively.)"*
- *L485-486: "(HECTOR only yields numerical stable results for −3.)"*
- *L495: "(For all versions and both PCA, the original and rescaled patterns are illustrated in Fig. S27–S29)."*
- *L507: "power spectral density (psd)" => psd, the abbreviation is already introduced.*
- *L510-511: "(Unlike our analysis, they did not co-estimate a quadratic or seasonal term.)"*

- *L548-549:"(The histograms and cumulative histograms for all basins are shown in Fig. S30 and S31, respectively.)*
- *L556-557: "(See also Table 2 for an overview of the various differences in firn thickness variations fv and their description.)"*
- *Fig1: I suggest to refer to Fig3 in the caption for basin locations.*

<u>Additional references:</u>

Marsaglia, G., Tsang, W., and Wang, J.: Evaluating Kolmogorov's Distribution, Journal of Statistical Software, 8, 1–4, https://doi.org/10.18637/jss.v008.i18, 2003.

Massey, F.: The Kolmogorov-Smirnov Test for Goodness of Fit, Journal of the American Statistical Association, 46, 68–78, 1951.

Miller, L.: Table of Percentage Points of Kolmogorov Statistics, Journal of the American Statistical Association, 51, 111–121, 1956.

REVIEW 2

1 Major concerns

The manuscript is very long and for a long time, I was unable to see where we were going and how all the notation, techniques, differences etc. were to be used. I realize that the authors want to be systematic by introducing all the methodology in Section 3 before using it in Section 4 and discussing it in Section 5. But this means that, until somewhere in Sections 4 and 5, I had been loaded with a large amount of notation, techniques etc. without really knowing why I needed to know this.

1.1 *Try to shorten the manuscript. I know you want to be thorough and systematic, but is there really no way of making it shorter? It is a very long read.*

- We have significantly shortened the manuscript, in particular the introduction and the data section. We have reduced the main text length from 741 lines to 581 lines.
- In addition, we have slightly modified our methods for ease of presentation and explanation, as previously described in the responses to the reviews. We now use the altimetric variations as input to our regression approach. We have therefore restructured the method sections as follows:
    3.1 Basic approach
    3.2 Principal component analysis of modelled firn thickness variation
    3.3 Regression approach
    3.4 Different versions of adjusted firn thickness variations
    3.5 Assessment methods
- Further, we have reduced the number of figures or subfigures. We have removed Fig. 2, 5a and 5f, 6, 9b, 10a, 11a-c, 12a-c and 16b.

1.2 *Somewhere in the beginning make an overview of what the problem is, and the pathway to solve it. Try to include a cartoon or flowchart showing the data coming in, all the intermediate products, the residuals, the analyses done on the residuals, and the use you make of these things. Include also the notation in each box of the chart and the relevant section numbers - not just where they are derived in Section 3 (as in Table B1) but also where they are calculated in Section 4 and used in Section 5. That would provide a road map for the reader making the journey through it all easier to navigate in.*

- We have included a flowchart showing the entire workflow together with the results, their notation, the section where the results are first presented and the main methodological steps to derive these results and the sections where the methods are explained.

2 Minor issues and typos

L53: SOME RCMs specialize…

- We have rephrased: "When the main goal of RCMs is to realistically simulate the ice sheet weather, as is the case here, they are forced by atmospheric reanalysis products and thoroughly evaluated against hundreds of in situ observations of SMB (van Wessem et al., 2018; Agosta et al., 2019)."

L178: ERA5: What is the resolution of ERA5? 31 km, right? And this is "downscaled" to 27 km, right? Please argue why? Do you have reason to believe the 27 km RACMO data is better than the 31 km ERA5 data as input to the FDM?

- Please see our response to the review.

L181: MERRA2 is downscaled from what resolution to 12.5 km? And how?

- Please see our response to the review. As the downscaling was part of the NASA Downscaling Project (Tian et al., 2017), we have added this reference to the description of the firn model.

L262: The sentence starting with "Observations" is very difficult to read. Perhaps start with the fact that you find higher noise levels from the older sections and use this to motivate why you introduce a weighting. Also, say which variable (r^A?) represents this noise you talk of.
L265-269: This is very difficult to understand. Please see if you can rewrite it more clearly.

- We have rephrased the whole paragraph (L262-268) and have also considered the comment on L321: "The stochastic model of our regression in Eq. 1 prescribes a different weighting of observations from two time periods. As results from the older altimetry missions generally have a higher noise level (Schröder et al., 2019a; Nilsson et al., 2022), hv^A after 2003 are weighted by 1, while hv^A before 2003 are given a different (usually lower) weight, which is defined, individually for every grid point, by the ratio of the noise variance of hv^A before and after 2003. We assess the noise by the high-pass filtered version of hv^A separately for both periods (cf. Groh et al., 2019). The high-pass filtering consists of removing a low-pass filtered version of hv^A, where the low-pass filter is a Gaussian filter with a 6σ = 12 months filter width."

L321: "deterministic": What do you mean by deterministic? And later on (L669+673), you talk of "stochastic". Exactly what is stochastic? I cannot see any noise terms added anywhere in your methodology.

- Please see our response to the review. The term stochastic model should now be clarified through the rewording of paragraph L262-268 (see above).

L371-375: Was very difficult to read. I think I understood it when the results were shown later on, but when reading it here I did not get it.

- We have included concrete matrix sizes for clarification: "The first PCA is applied to four versions of standardised residuals (r^{A1a}, r^{A1b}, r^{A2a}, r^{A2b}). The second PCA is applied to two versions of standardised residual differences (r^{A1a}–r^{A2a} and r^{A1b}–r^{A2b}). For each PCA, we set up one aggregated 'super data matrix' in which we arrange the time series for each grid cell and each version into a single set of time series. Specifically, our data sets comprises m = 90638 points in space (entire area under investigation) and p = 108 points in time (2003–2017). Thus, for the first and second PCA, the super data matrix has the size of 4m x p and 2m x p, respectively. The PCA is conducted to identify the dominant temporal patterns (PCs), which are shared by all versions, together with their space-dependent and version-dependent spatial patterns (EOFs). Each identified mode thus consists of one joint PC (1 x p) and four, or two, EOFs (4m x 1 or 2m x 1) in the case of the first, or second, PCA, respectively."

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L380: You say that the fv^Ma are standardized prior to PCA, but in Fig 4 you say that the EOFs have units of m. How can the EOFs have units if the input is standardized and thereby non-dimensional?

- We have removed the unit of meter in Fig. 4.

Fig 7: Why are d-f not identical (or at least similar) to the EOFs in Fig 4? Are you not projecting the model signal on to the PCs that came out of a PCA on exactly that signal? Should that not be a way of recovering the EOFs, i.e., by projecting the signal onto the PCs? Or does it have to do with standardized vs non-standardized signals?

- First, we now explain the relation between the EOFs and the scaling factors in a simpler way: "To regain interpretable magnitudes of the EOFs, the EOFs are multiplied by the std of the time series of fv^M for each grid cell, which was previously used for standardisation. After this restoration of the signal amplitudes, we no longer speak of EOFs but of modelled scaling factors, e^M."
- Second, we now note in Fig. 7 (referring to the submitted manuscript): "(d–f) is the same as Fig. 4a–c but with restored signal amplitudes for each grid cell."

L455: What is R_s? I cannot remember having this introduced before.

- We have corrected this to R^2.

L482: "IS closer to"

- We have rephrased: "We find a stronger autocorrelation for the time series of fv^{A1a} than for that of r^{A1a}, (…)"

L712: The sentence starting with "We deliberately" does not read well. Particularly the word "deliberately" seems odd. Please try to rephrase the sentence.

- We have rephrased: "We developed a new approach that combines satellite altimetry and firn modelling results to resolve Antarctic firn thickness variations at a high temporal and spatial resolution, namely by monthly 10 km grids."

L723: outperforms

- We have rephrased: "The adjusted firn thickness variations, fv^A, outperform …"

L725+731: The sentences "However, one caveat should be noted." are a bit odd and short. Suggest you combine them somehow with the sentences coming after.

- We have deleted "one caveat should be noted" and we have combined "However" with the following sentence.

L734: "evaluated AT grid cell level"

- We have rephrased it as: "Over all grid cells of Antarctica, median absolute and relative (…)"

L735: Perhaps underline that the basin 5 and 8 numbers are also calculated at grid cell level as in the previous sentence.

- We have rephrased it as: "Over all grid cells of individual basins, the median relative uncertainties (…)"

L746: Do you not rather subtract the modeled firn thickness variations from the altimetric variations? That is what eqn A1 says, but your text says the opposite.

- We have corrected that to: "(…), we simply subtract the modelled firn thickness variations, fv^M, from the altimetric variations, hv^A, (…)".

L791: Where can the IMAU-FDM data be found?

- We have added the following information to the data availability statement: "The code of the firn model from Veldhuijsen et al. (2023) is available at https://github.com/brils001/IMAU-FDM and https://zenodo.org/records/5172513 (Brils et al., 2021). The firn model data from Veldhuijsen et al. (2023) and the results of this study can be obtained from the authors without conditions."

The following comments refer to sentences or parts of the manuscript that have been deleted and are no longer included in the revised version. Therefore, these comments are no longer addressed point by point. Explanations and replies to specific comments and questions have been provided in the response to the review.

- *L204: The use of parentheses and the two short sentences "Rates…" and "The three…" is quite clumsy here. Please rephrase.*
- *L206: "evaluated by comparing to"*
- *L214: Try to think of a better title for this sub-section*
- *Eqn 1, 2, and 4: These equations all include a, b, c, d1, …, but they are different (and subject to different regressions) in the three equations, right? Either change the notation or write this out very clearly.*
- *L478: "underlying time series IS displayed"*
- *L635: The sentence starting with "Thus, the …" is difficult to understand.*
- *L735-736: The sentence starting with "Across basin 8" makes it sound as if you only did this spatial analysis over basin 8, but didn't you do it over all basins?*
- *L736: Suggest to combine the sentence starting with "The large" with the one before.*

All the following comments will be revised as suggested.

- *L219 (and many other places, e.g., 401): The use of parenthesis after a full stop is not the usual way of doing it. Either a parenthesis refers to and is part of the sentence that is full-stopped, or maybe it should not be a parenthesis at all.*
- *L294: "scale it SUCH that"*
- *L481: "HAS stronger"*
- *L601: includes*
- *L691: "in THE snow"*
- *L733: resolveS*
- *L736: "are due" should perhaps be "are likely due" or some other modifier to weaken the claim.*
- *L745: "TO the original"*

Additional references:

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