

Dear Dr. Wenfeng Chen,

Thank you for the revised version. You will see that both reviewers recommend minor revision and I generally concur with their assessments. Please pay careful attention to their remarks (see also appended manuscripts), as well as my own comments in another appended manuscript (mostly pertaining to your figures). Please detail in an authors's response the comments by the reviewers and myself, and the actions taken by you and your colleagues.

A final recommendation of acceptance will perhaps be facilitated by another editor as I will shortly leave for Antarctica.

Best wishes,

Arjen Stroeven

Dear Editor Arjen Stroeven,

Thanks for your prompt and professional process of our manuscripts. We have carefully addressed all the comments from you and two reviewers. Our point-by-point responses are attached below in blue, while the original reviewers' comments are in black. Wish you a nice experience in Antarctica!

Sincerely,  
Wenfeng Chen

**Comments from Editor Arjen Stroeven**

Line 97: "Covering with" -> "and"

Corrected.

Line 98: (for location, see a)

Added.

Line 101: Here, and elsewhere, "m a.s.l."

Corrected.

Line 123: ITBOV or ITIBOV?

It's ITIBOV, we have corrected throughout the manuscript.

Line 165: "." Remove

Removed.

Line 165: SRTM v4.1

Corrected.

Line 165: direct to an open database instead?

Yes, this link is direct to an open database, the data is shared by Google Drive.

Line 212: define MAE

It's mean absolute error, and we have defined it.

Line 240: sigma? Refer to panel d

It's sigma, we have corrected it.

Line 255: explain abbreviations used in the caption: RMSE etc..

We have added the definition of abbreviations in the caption.

“In bottom panel, ME is Mean error, MAE is mean absolute error, Median is median error, RMSE is root mean square error, STD is standard deviation, and NMAD is normalized median absolute deviation.”

Line 255: “dash line” -> “dashed lines”

Corrected.

Line 273: Standard deviation (m)

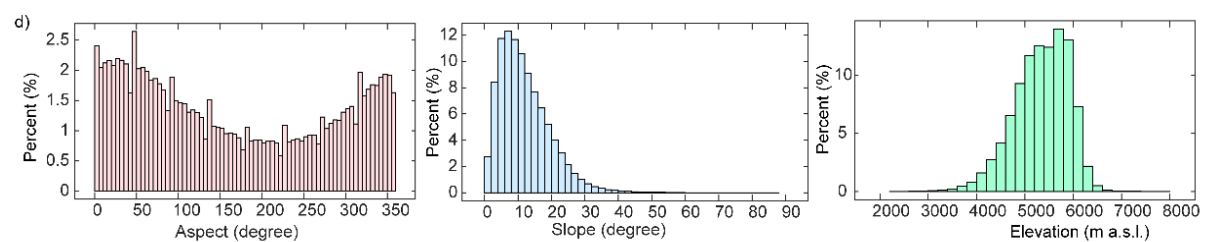
Corrected.

Line 275: “.”

Added

Line 297: these values don't seem to fit aspect and slope in (d)? Aspect appears to be binned by 10 degrees and slope I'm unsure but >2?

Figure 6d is updated. Now the bin gap is consistent with Figure 6a–c.

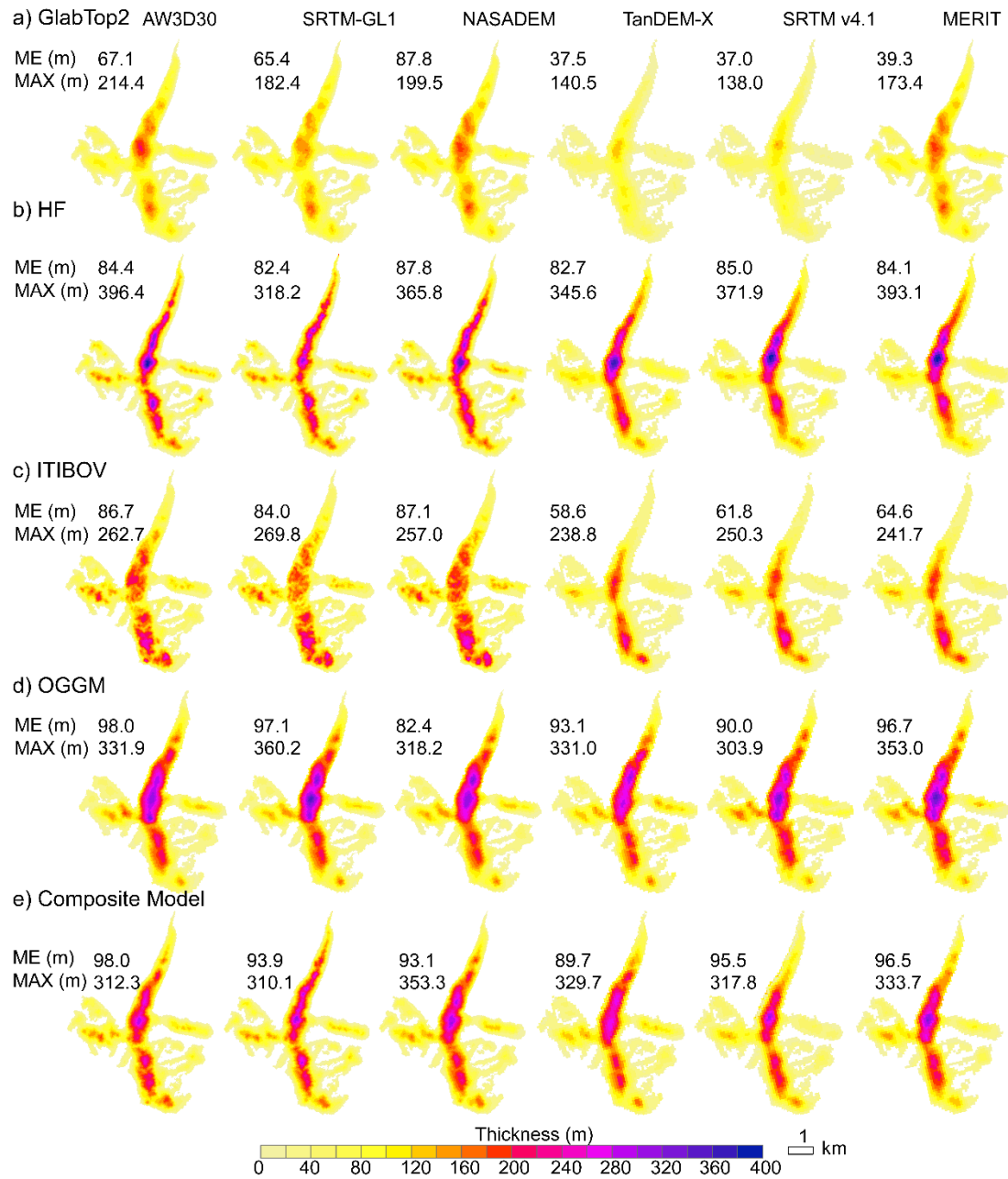


Line 321: that-> as

Corrected.

Line 343: please make sure that all scales have the same range (so that the same color in all panels mean the same ice thickness. Hard to compare otherwise.

We have improved this figure, using the same scale range for all subplots.



Line 356: ITBOV in figure

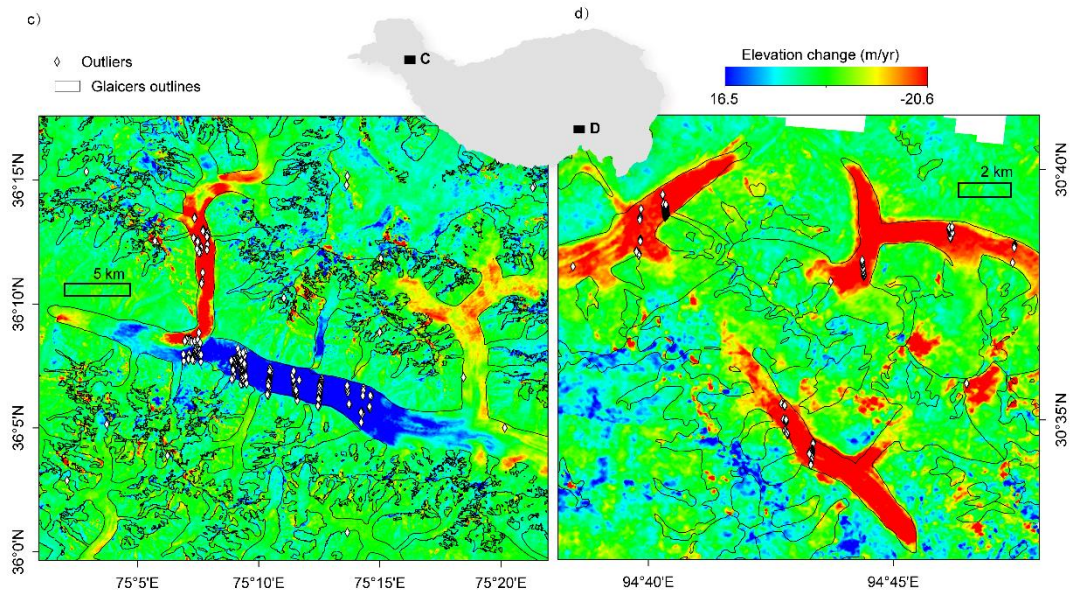
Corrected.

Line 365: spell out RMSE

Added.

Line 383: would it not make more sense to label them C and D to refer to panels c and d?

Figure 10 is improved.



Line 406: m a.s.l.

Corrected.

Line 455: “Figure 8 and 9” -> “Figures. 8, 9”

Corrected.

Line 575: “make” -> “made”, “estimate” -> “estimated”

Corrected.

### Reviewer #1

Comments on “Towards ice thickness inversion: an evaluation of global DEMs in the glacierized Tibetan Plateau” by Wenfeng Chen et al.

#### General Comments

The authors have made good efforts to address my comments on the previous version of the manuscript. They answered all my questions. It should be noted that my review and comments mainly focus on evaluation of DEMs using ICESat-2 and influence of DEMs on the inversion quality. The evaluation of the influence of the various inversion models on the thickness is out of my expertise.

One point that still needs to be addressed is introduction of the ground penetrating radar (GPR) data used for validation of the inversed thickness, in terms of equipment, location distribution, acquisition time, and quality. It may be a short subsection in the data section. There should be a clarification later as how they are used for validation. After addressing the GPR point and following minor edits, the manuscript is good for publication from my point of view.

We thank the reviewer for the valuable comments and suggestions, which improved our manuscript a lot. The GPR data used in this study is acquired from Azam et al. (2017), and this data is open

access at Farinotti et al. (2021). Detailed information about the GPR data is introduced by Azam et al. (2017). We have added one sentence in Section 2.3.

*“The GPR data were measured based on a pulse radar system in October 2009 (Azam et al., 2017) and is available at Farinotti et al. (2021).”*

**Reference:**

Azam, M.F., Wagnon, P., Ramanathan, A., Vincent, C., Sharma, P., Arnaud, Y., Linda, A., Pottakkal, J.G., Chevallier, P., Singh, V.B., & Berthier, E: From balance to imbalance: a shift in the dynamic behaviour of Chhota Shigri glacier, western Himalaya, India. *J GLACIOL*, 58, 315-324, <https://doi.org/10.3189/2012JoG111123,2012>

Farinotti, D., Brinkerhoff, D.J., Fürst, J.J., Gantayat, P., Gillet-Chaulet, F., Huss, M., Leclercq, P.W., Maurer, H., Morlighem, M., Pandit, A., Rabatel, A., Ramsankaran, R., Reerink, T.J., Robo, E., Rouges, E., Tamre, E., van Pelt, W.J.J., Werder, M.A., Azam, M.F., Li, H., & Andreassen, L.M.: Results from the Ice Thickness Models Intercomparison eXperiment Phase 2 (ITMIX2). *Front. Earth. Sci.*, 8, <https://doi: 10.3389/feart.2020.571923>, 2021

**Specific comments:**

There are some minor edits in the attached PDF.

Our point-by-point responses are attached below in blue, while the original reviewers' comments are in black.

Line 102: GPR data are critical for validation of thickness. Please add a section to describe GPR data, their sources, acquisition, distribution, and accuracy...

As response above, the GPR data used in this study is acquired from Azam et al. (2017), and this data is now available at Farinotti et al. (2021). Detailed information about GPR data is introduced by Azam et al. (2017). We add one sentence in Section 2.3.

*“The GPR data were measured based on a pulse radar system in October 2009 (Azam et al., 2017) and is available at Farinotti et al. (2021).”*

Line 105: is

Corrected.

Line 130: Delete "optics or SAR"

Done.

Line 161: Elevations ... are ... Elevations of other four ... are ...

Corrected.

Line 229: Change "exactly know" to "estimate".

Corrected.

Line 232: Change it to "4 sigma"

Corrected.

Line 280: Be consistent with "~" and "?+-".  
It should be -1 to 1 m, we have corrected it.

Line 405: Please add above conditions.  
Corrected.

*“Therefore, we conclude that the seasonal fluctuations of ICESat-2 data have little influence on the assessments of the DEMs under the above conditions.”*

Line 449: Grid spacing. Same for the later cases.  
Corrected.

## **Reviewer #2**

The manuscript has considerably improved. Still many small details remain to be fixed, most of them related to grammar and spelling. All my comments are included in the annotated pdf. In general I think the results are relevant and the approach is sound, and I therefore recommend publication after minor revisions.

We thank the reviewer for the positive evaluation of our manuscript.

Line 21: increased -> increase  
Corrected.

Line 23: Then -> In a next step,  
Corrected.

Line 25: It is unclear how the second part of the sentence connects to the first. Please reformulate or just remove the first part of the sentence.  
We have removed the first part of the sentence.

Line 25: “Our assessment first figures out the performances of mainly global DEMs over the glacierized TP.” This may be removed. It is already clear from the earlier part of the abstract.  
We have removed this sentence.

Line 27: Also this is rather obvious and may be deleted.  
We agree with the suggestions from the reviewer and deleted this sentence.

Line 52: Overestimate -> overestimation  
Corrected.

Line 53: No need to mention this, it is obvious from the previous.  
We agree with the suggestions from the reviewer and deleted this sentence.

Line 54: Is this with GlabTop or another model? Please specify.

We have added “... using *Huss-Farinotti model (Huss and Farinotti, 2012).*”

Line 55: Not sure what is meant here. Please clarify or remove.

We have removed this sentence.

Line 55: most -> several, has -> have

Corrected.

Line 70: “and complicated” delete

Deleted

Line 73: DEM with high resolution is also of limitation -> high resolution DEMs are of lower quality

Corrected.

Line 74: DEM -> DEMs

Corrected.

Line 76: public freely-accessed -> open-access

Corrected.

Line 79: their studies -> Liu et al. (2019)

Corrected.

Line 103: Descriptions of ICESat-2 elevation data referenced -> ICESat-2 elevation data

Corrected.

Line 108: ICESat-2 -> ICESat-2's

Corrected.

Line 105: product both can -> products can both

Corrected.

Line 109-110: TL03 -> The ATL03

Corrected.

Line 110: considering -> based on

Corrected.

Line 110: Compute -> Computational

Corrected.

Line 127: Descriptions of global-scale DEMs evaluated -> Global DEMs

Corrected.

Line 129: evaluating their influences on ITIMs -> evaluation of ITIM sensitivity

Corrected.

Line 141: and the influence of ablation and accumulation of glaciers should also be noted. -> inducing errors due to (seasonal and long-term) accumulation / ablation on glaciers.

Corrected.

Line 160: method -> methods

Corrected.

Line 170: Some more information or a reference for the GPR data would be useful.

We have added one sentence and one reference here.

*“The GPR data were measured based on a pulse radar system in October 2009 (Azam et al., 2017) and is available at Farinotti et al. (2021).”*

Azam, M.F., Wagnon, P., Ramanathan, A., Vincent, C., Sharma, P., Arnaud, Y., Linda, A., Pottakkal, J.G., Chevallier, P., Singh, V.B., & Berthier, E: From balance to imbalance: a shift in the dynamic behaviour of Chhota Shigri glacier, western Himalaya, India. *J GLACIOL*, 58, 315-324, <https://doi.org/10.3189/2012JoG11J123,2012>

Line 171: “:”-> “.”

Corrected.

Line 172: Start new paragraph here.

Corrected.

Line 173: bottom -> basal

Corrected.

Line 180: “The”

Included.

Line 214: This should be in bold text.

Corrected.

Line 215: measurement -> measurements

Corrected.

Line 216: outside -> greater than

Corrected.

Line 218: assessments -> analysis

Corrected.

Line 222: change ranged between



Corrected.

Line 223: acquiring -> acquisition, DEM -> DEMs

Corrected.

Line 223: error due to the glacier dynamic -> errors due to the changing glacier geometry.

Corrected.

Line 224: “TanDEM-X and AW3D30 are acquired in different months and years (Table 1), it’s hard to analyse the impact of glacier dynamic on accuracy assessment” -> “This applies in particular to TanDEM-X and AW3D30, which are collected in different months and years.”

Corrected.

Line 226-229: “The way this is formulated is confusing. In case the difference between ICESat-2 data and DEMs is used to correct the ICESat-2 data then the errors would reduce to zero when comparing DEMs and corrected ICESat-2 data. But I suppose that is not what is meant here. Please clarify what adjusted ICESat-2 means.”

The adjusted ICESat-2 means the ICESat-2 elevation plus the glacier elevation change magnitude during 2000-2020. We have improved this sentence.

*“Then the glacier elevation dynamic magnitude during February 2000 and February 2019/2020 (Shean et al., 2020), are subtracted from the selected ICESat-2 elevation. By comparing the elevation differences from the adjusted ICESat-2 and the four DEMs, we could partly estimate the impacts of glacier dynamic on accuracy assessment.”*

Line 233: ration- ratio

Corrected.

Line 246: differed little -> did not differ much

Corrected.

Line 254: It seems like that nearly all dashed lines (showing mean elevation difference) are too far to the right, i.e. that more than 50% of the area under the graph is on the left side of the dashed line. I could be wrong... Are the mean differences here corrected for glacier height change between acquisition dates or not (I was a bit confused by the description in the methods on this)?

In fact, we are aware that the elevation difference is affected by the glacier elevation change. The mean differences here are not corrected for glacier height change between acquisition dates. However, in the Discussion section, we estimated the influence from glacier dynamic on accuracy assessment.

Line 254: One dashed line has the wrong color.

Corrected.

Line 262: the nearly same -> nearly the same

Corrected.

Line 266: Thereinto?

Deleted.

Line 267: minimum -> smallest

Corrected.

Line 267: This sentence is not clear in its current form

This sentence was improved.

*“The STD of NASADEM was improved over the most part of TP, compared with that of SRTM-GLI (Fig.5b)”*

Line 268: indicate -> indicates

Corrected.

Line 270: improvement (?) Compared to what exactly?

The sentence is reformulated.

*“...large improvements in STD...”*

Line 271: are almost same in space -> have the same spatial distribution

Corrected.

Line 271: “corresponding to their” -> “and have”

Corrected.

Line 279: amplitude -> amplitude is found

Corrected.

Line 285: serious -> steep

Corrected.

Line 288: behave best against the slope -> perform best for steep slopes

Corrected.

Line 292: show the similar -> show a similar

Corrected.

Line 295: high elevation region -> highest elevations

Corrected.

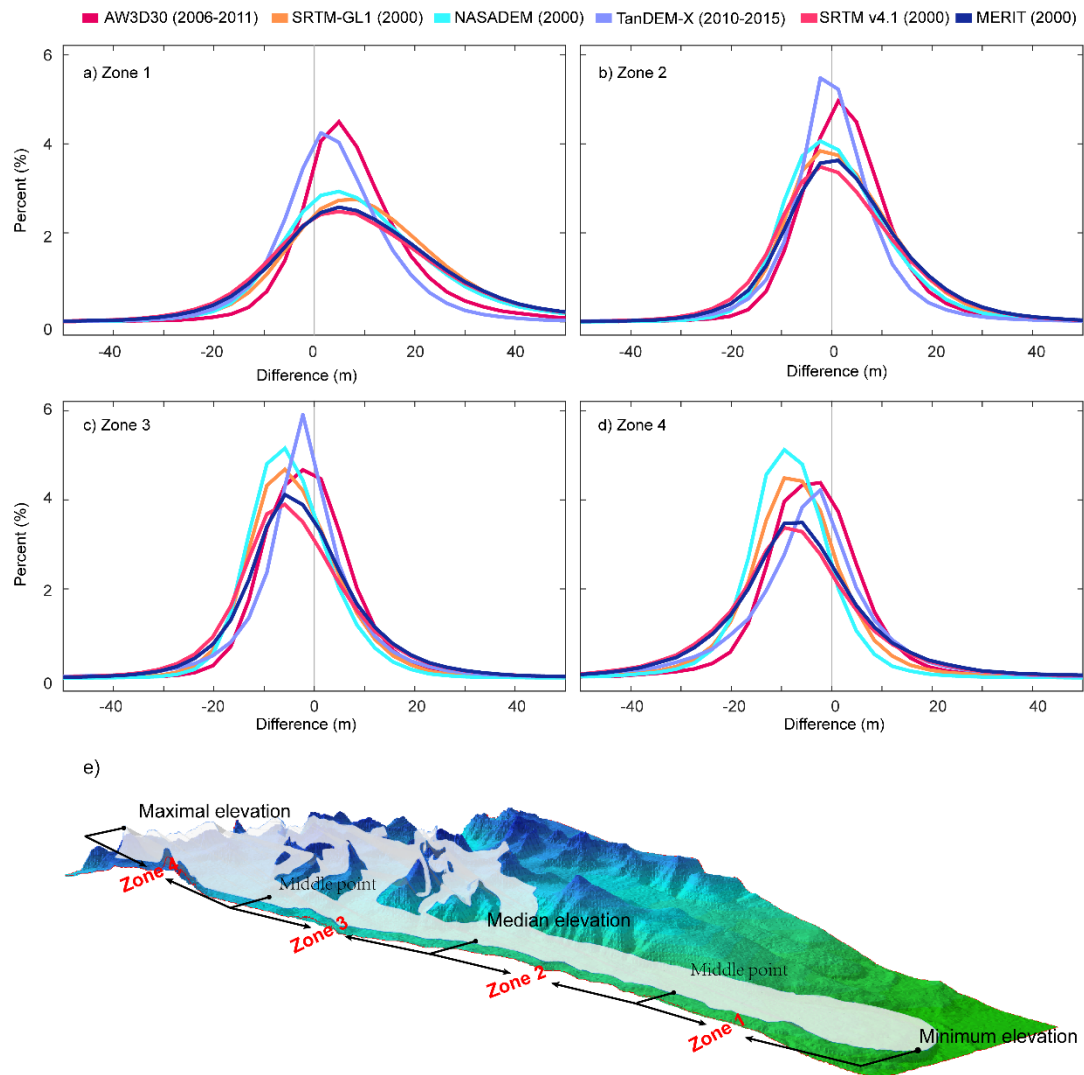
Line 300: Differences -> Elevations differences

Corrected.

Line 314-315: It could help to include the acquisition dates somehow in Fig. 7. That makes the

figure much easier to interpret.

We have improved Fig.7 a-d.



Line 324: The DEMs do not "model" the ice thickness, please rephrase, e.g. "Sensitivity of modelled ice thickness to DEMs"

We have changed the title of Section 3.4 to "Sensitivity of modelled ice thickness to DEMs"

Line 327: on specific ITIMS -> "on ice thickness estimated using different ITIMS"

Corrected.

Line 332: from -> when

Corrected.

Line 333: maximal -> largest

Corrected.

Line 334: Minimum -> smallest

Corrected.

Line 339: weakness -> weaknesses

Corrected.

Line 339: 8, 7, 3 and 2 what?

We have improved this sentence.

*“NASADEM indicates better performance (number of smaller RMSE in five profiles) relative to other DEMs by using GlabTop2 and ITBIOV models. AW3D30 conducts better by using ITBIOV and OGGM models. TanDEM-X is better by using OGGM model. While five models are composited, NASADEM behaves better.”*

Line 350: The benefit of using all models (weighted) instead of one model could be quantified, i.e. how much smaller is the RMSE for all models combined when compared to the RMSE for one ITIM? The values are already in Table 2.

We add one sentence.

*“RMSEs of combined ice thickness modelled from different DEMs are reduced by ~21 m (~25%), when compared to the RMSE for one ITIM.”*

Line 370: in -> near

Corrected.

Line 390: So the results presented so far have not been corrected for different acquisition dates and related elevation change, right? It could be good to make this more clear earlier on in the manuscript. Yes, the results presented so far are not corrected for different acquisition dates and related elevation change as we cannot acquire the exact date of TanDEM-X and AW3D30. We state this information in Method section.

*“Then the glacier elevation dynamic magnitude during February 2000 and February 2019/2020 (Shean et al., 2020), are subtracted from the selected ICESat-2 elevation. By comparing the elevation differences from the adjusted ICESat-2 and the four DEMs, we could partly estimate the impacts of glacier dynamic on accuracy assessment.”*

Line 398: “the glacier melt and sublimate” -> “glaciers experience more melt and sublimation” ?

Corrected.

Line 399: “the glacier”-> “. As a result, the”

Corrected.

Line 399: “;then” -> “and”

Corrected.

Line 400: “fewer” -> less

Corrected.

Line 414: have a strong dependence -> depend strongly

Corrected.

Line 415: Not sure what is meant here... Why would the probability density of aspects matter? Please reformulate or remove.

We have removed this sentence.

Line 419: accordant distribution of data in different slopes with aspect -> predominance of slopes for certain aspects.

Corrected.

Line 435: serious -> substantial, with the output -> and the output appears

Corrected.

Line 440: "Pixels in DEMs do not represent exactly the same location." (?)

You are right, and we have corrected this sentence.

Line 447: No need to mention MATLAB here, but rather indicate what type of fit function / interpolation technique is used.

We have removed "in MATLAB", and added "nonlinear least squares" in this sentence.

Line 449: offset pixels -> misregistration

Corrected.

Line 449: are all at -> is always

Corrected.

Line 457: model -> ITIM

Corrected.

Line 457: have different outcomes -> will yield different thickness patterns

Corrected.

Line 458: uncertainty of DEM -> quality of a DEM

Corrected.

Line 459: maximal and minimum -> largest and smallest

Corrected.

Line 462-466: This is rather Results than Discussion. Furthermore, the way in which the perturbations are applied is not described if I am correct. It should be made clear whether perturbations are applied everywhere as a systematic perturbation or as random noise. Maybe I missed it...

Here, we described the sensitivity of GlabTop2 and ITIBOV models to slope and elevation. It could be better to be put in Discussion section. We have added one sentence to describe the sensitivity test.

*“A sensitivity test based on the Equations 1–4 was executed and the modelled ice thickness differences before and after adding the input parameters such as slope and elevation were compared.”*

Line 469: Is it ITIBOV or ITBOV? Please check consistency throughout the manuscript  
It's ITIBOV, we have checked throughout the manuscript.

Line 471: rather use “ice thickness” instead of “output”

Line 472: “the” delete  
Corrected.

Line 475: “motion” -> “transient dynamics”  
Corrected.

Line 476: “When the better accuracy of” -> “With the higher-accuracy”  
Corrected.

Line 477: “led to the relatively best outcomes” -> most accurate ice thicknesses were obtained  
Corrected.

Line 478: “results”-> “ice thicknesses”  
Corrected.

Line 479: “30-m DEMs compared with 90-m resolution DEMs” -> “using 30 m or 90 m DEMs as input.”  
Corrected.

Line 479: “means that high spatial resolution improved the outcome little”-> thereby suggesting a minor impact of DEM resolution on ice thickness reconstruction  
Corrected.

Line 479: “For” -> “In”  
Corrected.

Line 481: “For” -> “In”  
Corrected.

Line 486: models->ITIMs  
Corrected.

Line 487: not sure what is meant with this  
We have improved this sentence.

*“When the results from different ITIMs are ensembled, the influences of uncertainty and resolution*

*in the input DEMs on the modelled ice thickness still exist (Fig. 9 and Table 2).”*

Line 488: equipped with -> which have

Corrected.

Line 488: achieved -> yielded

Corrected.

Line 488: “best outcomes” -> “most accurate thickness estimates”

Corrected.

Line 490: the discord -> “spatial inconsistencies(?)”

Corrected.

Line 496: what’s more -> “Furthermore,”

Corrected.

Line 497: “as similar as” -> “, similar to what has been done in”

Corrected.

Line 526: best outcomes -> “most accurate thickness estimates”

Corrected.

Line 529: limited by -> “but with limitations from”

Corrected.