

## **Comments on**

**“Towards ice thickness inversion: an evaluation of global DEMs by ICESat-2 in the glacierized Tibetan Plateau” by Wenfeng Chen et al.**

## **Referee #2**

### **Overview**

This paper by Chen et al. presents a method to evaluate existing regional scale DEMs using the recently available ICESat-2 elevation product. The DEMs are then applied to model the ice thickness of glaciers in the Tibetan Plateau region. The quality of the inversion results is then analyzed to prove the effectiveness of the ICESat-2 based evaluation. The paper is generally well structured. It showed that the ICESat-2 data provided a comparison dataset for selecting an optimal DEM that can be used as input for ice thickness inversion. This work should be useful to researchers of The Cryosphere community. The paper needs to be revised according to the following major and minor comments.

The manuscript needs a serious improvement of both formal English writing and scientific meaning.

### **Major comments**

1. The subtitles in the Data and Methods sections need to be improved to reflect the actual contents and be logic (*ICESat-2 elevation data referenced, DEMs evaluated, .....*).
2. The ICESat-2 data were used to evaluate DEMs. It should be discussed how the DEMs were generated, including data sources, time periods, and uncertainties. During the time differences between the ICESat-2 data and MEDs there may be glacier surface changes that may affect the evaluation. If this is not considered, would this also affect the thickness inversion results?

3. ICESat-2 Level-3A land-ice ATL06 product was used in this work. There should be a good understanding of the quality of this product itself, although a systematic cal- val may not have been performed in the glacierized Tibetan Plateau region. I would like to see even a general discussion in that regard. I suggest to add some relevant references in the Data section:

Brunt, K. M., Neumann, T. A., and Smith, B. E.: Assessment of ICESat-2 Ice Sheet Surface Heights, Based on Comparisons Over the Interior of the Antarctic Ice Sheet, *Geophys. Res. Lett.*, 46, 13072–13078, <https://doi.org/10.1029/2019GL084886>, 2019.

Brunt, K. M., Smith, B. E., Sutterley, T. C., Kurtz, N. T., and Neumann, T. A.: Comparisons of Satellite and Airborne Altimetry With Ground-Based Data From the Interior of the Antarctic Ice Sheet, *Geophys Res Lett*, 48, e2020GL090572 <https://doi.org/10.1029/2020GL090572>, 2021.

Li, R., Li, H., Hao, T., Qiao, G., Cui, H., He, Y., Hai, G., Xie, H., Cheng, Y., and Li, B.: Assessment of ICESat-2 ice surface elevations over the Chinese Antarctic Research Expedition (CHINARE) route, East Antarctica, based on coordinated multi-sensor observations, *The Cryosphere*, 15, 3083–3099, <https://doi.org/10.5194/tc-15-3083-2021>, 2021.

Elevation differences between crossovers formed by ICESat-2 tracks may be used for the elevation accuracy evaluation.

As ATL06 product comes from ATL03 photons grouped in 40 m segments, would ATL03 data provide more terrain details? This may be outside of the scope of this paper. However, a discussion of this potential would be helpful to the readers in their future research.

4. Based on your results, the accuracy of ICESat-2 data is better than the compared global-scale DEMs. Have you considered to use the ICESat-2 data to improve the quality of the DEMs, especially in areas where ICESat-2 along and across track data are available. Again, this may be considered as a future work.

### **Minor comments**

**Page 1, Line 11:** Replace “derived” with “derived from”.

**Page 1, Lines 12–14:** This sentence is awkwardly phrased. You may rephrase by separating it in to two sentences.

**Page 1, Line 17:** Please be clear if it is the horizontal or vertical accuracy.

**Page 1, Lines 23-24:** Change “one pixel” to one grid spacing.

**Page 1, Lines 24-28:** These sentences are not communicating well. Please cut them to short and simple sentences.

**Page 2, Lines 33 & 36:** Change “km2 ”, “km3 ” to “km<sup>2</sup>”, “km<sup>3</sup>”.

**Page 3, Line 87 and Page 4, Lines 107-108:** When you mention ICESat-2 in these two places, please mention the cal-val efforts and introduce the most recent accuracy assessment results by Brunt et al. (2019, 2021) and Li et al. (2021).

**Page 4, Line 95:** Replace “intersecting” with “covering”.

**Page 4, Line 105:** ~17 m diameter is the design value. This value needs to be updated according to the new study: Magruder, L. A., Brunt, K. M., and Alonzo, M.: Early ICESat-2 on-orbit geolocation validation using ground-based corner cube retro-reflectors, *Remote Sensing*, 12, 3653, <https://doi.org/10.3390/rs12213653>, 2020.

**Page 4, Line 106:** In addition to first-photon bias, transmit-pulse shape correction should be mentioned also.

**Page 5, Line 115:** The ATL06 data provide slopes in along and across tracks. They are derived at different scales (along track with denser points and cross track with fewer points and longer separations). Have you considered the difference between these two types of slopes?

**Figure 2:** “Difference in aspect and slope bins”.

**Figure 2:** Make different blue boxes into just blue color.

**Page 6, Line 127:** Please specify how severe is the gap situation and the effectiveness of gap filling.

**Page 6, Line 135:** All website links need to add the last visit date to ensure their availability.

**Page 8, Lines 160-162:** The sentence is unclear. Please rewrite.

**Page 10, Line 209:** Please justify your choice of 4-std of differences between ICESat-2 and DEMs for data filtering.

**Page 10, Lines 212 & 214:** “R<sup>2</sup>”

**Page 11, Line 219:** “R<sup>2</sup>”

**Figure 3 & Figure 4:** Why would RMSE in both figures be different? For example, for AW3D30 it is 13.4 m in Fig 3, but it is 34.9 m in Fig 4. Please make sure the data are consistent throughout the paper.

**Page 12, Line 240:** “The ME in the Himalaya is more negative than that in southeast Tibet”, but it is not clearly shown in Figure 5. Do you want to quantify it with numbers?

**Page 12, Line 243:** Please be clear about “spatially relevant”.

**Page 15, Line 278:** The time of six DEMs is all earlier than the ICESat-2 data. As stated in the major comments, in addition to uncertainties would temporal changes of the glaciers also affect your evaluation efforts?

**Figure 6:** No significant information is presented in Fig 6(d). You may just deleted it.

**Page 16, Line 309:** Replace “that is” with “they are”.

**Page 16, Line 317:** Explain the numbers of “9, 3, 4, 3 and 1”.

**Figure 10(a):** The figure displays the proportion of outliers vs. slopes. Within the range of 55-90 degrees, the proportion is up to ~40-55% for six DEMs. This is a high percentage. Would you please discuss the reasons?

**Page 21, Line 384:** “ICESat-2 elevation is ... higher in Fig. 11d”. This statement is not true in Fig.11d. Please describe the figure accurately and objectively.

**Page 22, Line 393:** Remove “will”.

**Page 22-23, Lines 401-402:** Remove the sentence “Additionally, ... elevation”. The error of these two scatterings cannot influence the magnitude of the biased estimate of elevation you mentioned here.

**Page 26, Line 449:** Explain how is this correction of sub-pixel misregistration performed.

**Page 27, Line 470:** Change “A +5° error” to “An error of +5°”.

**Page 28, Lines 495-497:** I cannot get what you mean here. Rewrite it to make it clear.

**Page 29, Lines 527-529:** It is not clear what you want to say here. It is in the conclusions section. You need to be brief and direct. Please rewrite.