

The Cryosphere Discuss., referee comment RC1  
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## **Comment on tc-2021-102**

Anonymous Referee #1

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Referee comment on "Improving surface melt estimation over the Antarctic Ice Sheet using deep learning: a proof of concept over the Larsen Ice Shelf" by Zhongyang Hu et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-102-RC1>, 2021

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## **Review of "Improving Surface Melt Estimation over Antarctica Using Deep Learning: A Proof-of-Concept over the Larsen Ice Shelf" by Zhongyang Hu et al.**

The Cryosphere Discuss. Manuscript Number: tc-2021-102

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### **General comments:**

This paper demonstrates that the estimations of the Antarctic ice sheet surface melt volumes by the regional climate model RACMO2 can be improved significantly if a deep multilayer perceptron (MLP) model is employed to correct the RACMO2 simulation results. In recent years, various types of machine learning techniques, which include the MLP model, also known as artificial intelligence (AI) are widely used in many directions in accordance with improved performance of computers as well as rapid increases in relevant data size. Therefore, the topic addressed by the authors is opportune. As far as I know, such an attempt is very new in the glaciological research community. In this respect, this study is of high value. In addition, this informative paper is well written and organized. Therefore, this reviewer recommends its publication in the journal TC although several points in the paper can be improved prior to its publication. Please find below my specific comments and suggestions on the paper.

### **Specific comments:**

Title: Suggest rephrasing "Antarctica" -> "Antarctica Ice Sheet". I think it is better to state explicitly that "ice sheet" surface melt is investigated in this study.

L. 3: "simulations": simulations with a climate model? Please clarify.

L. 11: "XGBoost", Its definition is needed here. In my opinion, most readers of the journal TC are not so familiar with machine learning methods.

L. 14: "the heterogeneous drivers of melt": Its intention is unclear to me. Can the authors describe it more concretely?

L. 45: "remote sensing albedo observations" It is worth to mention MODIS here.

L. 60: "scatterometry": Can the authors specify the type of the sensor used for the comparison?

L. 60 ~ 61: "RACMO2 melt can be both higher and lower than observations": depending on what conditions? More detailed explanations are useful for readers.

Figure 1 caption: "The elevation information ~": "The elevation information for tundra areas ~"?

L. 85: Section 2.2.2: I would like to confirm whether the authors considered possible factors that can disturb albedo measurements (e.g., tilt of the AWS mast and/or sensors, surface hoar, etc) and corrected the measured albedos.

L. 85: Please explain whether the ice surface appears or not during the austral summer ablation period at each AWS.

L. 89 ~ 90: "Air temperature (T2m), air pressure (p), and relative humidity (RH) ~": It is better to indicate that they are measured at the surface.

L. 98: "evolution of surface albedo": The following description on "surface albedo" (The albedo scheme is based on the metamorphism of snow grains determining the amount of

incoming radiation that is absorbed in the snowpack) is only on "snow albedo". Therefore, indicating explicitly like "evolution of snow albedo" is better.

L. 111 ~ 112: "The MODIS albedo itself is corrected for variations in solar zenith angle, and cloud cover (Figure 2 Block II-3) to allow comparison with the RACMO2 albedo.": Its intention is a bit unclear. In the previous part, the authors state that white-sky albedo from MODIS is used in this study, so, can I assume that the authors converted white-sky albedo to (blue-sky) albedo in this process? Please clarify.

Figure 2 caption: What is the difference between solid and dashed lines?

L. 141 ~ 143: It is useful for readers if the authors briefly describe how the calibration was performed.

L. 161: As seen later in Fig. 7, discrepancies between in-situ measured and MODIS albedos are often found at all the AWSs. I would like to know the authors' thoughts regarding whether the deep MLP model performance can be improved if the accuracy of MODIS albedo (e.g., RMSE) is somehow considered here (e.g., input monthly RMSE values of MODIS albedo). If the authors can add some comments on this issue in Sect. 5, it will be useful for readers.

L. 192: "the MODIS white-sky albedo product (MCD43A3) is a clear sky product": In my humble opinion, this description is incorrect: White-sky albedo is defined as albedo in the absence of a direct component when the diffuse component is isotropic.

L. 258: "0.21 lower in no-melt conditions": compared to what? It seems to me that the authors compare melt and no-melt periods here. If so, the value must be 0.24.

L. 261: "'handle' of the 'sword'": I could understand the intention of "sword"; however, the intention of "handle" is unclear to me.

L. 281: "neural network": This technical name appears for the first time in this paper here. I think it should be introduced much earlier in this paper.

L. 307: "clear-sky": How did the authors confirm the "clear-sky conditions"? Also, do the authors mean this is in-situ measured information? Or model simulation results? Please clarify.

L. 333: clear-sky" -> "white-sky"; "all-sky" -> "blue-sky". Also see my comment on L. 192.

L. 381 ~ 382: "It is plausibly due to the overestimations in 2m air temperature by RACMO2 simulations (Figure 11a).": If the deep MLP model is implemented in RACMO2, and a fully two-way coupled configuration between RACMO2 and the deep MLP model becomes possible, do the authors think that the overestimation can be solved? Please discuss.

L. 452: "the state-of-the-art deep learning architectures and models": Please specify them more in detail.

### **Technical corrections:**

When refereeing a figure in running text, the abbreviation "Fig." should be used when it appears in running text and should be followed by a number unless it comes at the beginning of a sentence. See the following link for more in detail:  
<https://www.the-cryosphere.net/submission.html#figurestables>  
Please check throughout the manuscript carefully again.

L. 12: "the resulting,": The comma is unnecessary?

L. 63: "The Antarctic Peninsula is the mildest region of Antarctica ~" -> "The Antarctic Peninsula (Fig. 1) is the mildest region of Antarctica ~"

L. 81: "demonstrate": I think using "confirm" instead of "demonstrate" is better here.

L. 82: "as an indicator surface melt" -> "as an indicator of surface melt"

L. 86: "AWS 14, AWS 17, and AWS 18 are automatic weather stations ~" -> "AWS 14, AWS 17, and AWS 18 (Fig. 1) are automatic weather stations ~"

L. 87: "Shortwave radiation" Add "down- and upwelling" before this.

L. 107: "done" -> "performed"; Using a formal word is better in a scientific paper.

L. 138: "the ground heat flux" -> "the subsurface conductive heat flux"; I assume the authors do not consider interaction between the ice sheet and the ground (bedrock).

L. 252: "Figure 4" -> "Fig. 4a"

L. 254: "0.95 and 0.42" Indicate these values with units in the text.

Figure 5 caption: In my humble opinion, "Dynamics of" should be rephrased to something like "Temporal changes in"

Figure 7 caption: Same as the comment on the Figure 5 caption.

Figures 10 and 11: Most of the captions can be omitted by referring to the caption of Fig. 9.