Reviewers' Comments:
Reviewer: #1
This study utilizes ICESat-2 data from November 2018 to November 2019 to generate a new DEM over Greenland, and validates the newly generated DEM with IceBridge ATM data obtained in May 2019. This study also presents a comparison of different DEM products. I think that this paper is interesting and the topic is suitable to ESSD. However, several major comments should be seriously considered.

We thank you for the helpful feedback, these suggestions have significantly improved the text and figures, we are appreciative of your help and time.

Major comments:

1. The present language quality is not good enough and needs to be improved throughout. For example, Page 1 Line 10-11, "but long temporal coverage introduced additional time uncertainty to scientific research", what does time uncertainty mean? Line 11-12 "with a definite time", what does it mean? Page 2 Line 49, "Hence"? Page 3 Line 97, "by different beams"? Page 9 Line 253, "Of these" should be "Among them".

Responses: We have changed the structure of the article and some statements in the article, and these parts are shown in red in the revised version.

(a) Page 1 Line 10-11, "but long temporal coverage introduced additional time uncertainty to scientific research", what does time uncertainty mean?

Responses: Time uncertainty refers to temporal resolutions. The long timespan of applied source data leads to the low temporal resolutions of previous DEMs. When it was applied to calculate elevation and mass changes, it is hard to quantify the years when these changes occurred.

Line 11-12 "with a definite time", what does it mean?

With a definite time means that ICESat-2 DEM has a specific time-stamp (e.g May 2019).

(b) Page 2 Line 49, "Hence"?

Responses: We changed the sentence to 'In addition, owing to the wide coverage (86°N-86°S), high single-point accuracy (0.1-0.15 m), and small footprint size (70 m) (Zwally et al., 2002), ICESat has the ability to measure the elevation of entire Greenland.'

(c) Page 3 Line 97, "by different beams"?

Responses: We changed the sentences to 'Hence, we included weak beams to increase spatial coverage and data point utilization due to no systematic errors were found in strong and weak beams in ICESat-2 elevation measurements.'

(d) Page 9 Line 253, "Of these" should be "Among them"

Responses: Accept and revised.

2. The resample resolution of IceBridge is about 25 m, how to validate the ICESat-2 DEM with different spatial resolution (namely, 500 m, 1 km, 2 km). Please clarify.

Responses:

One ICESat-2 DEM grid cell usually has several IceBridge measurement points. In each grid cell, the ICESat-2 DEM elevation values were subtracted from the median of all IceBridge elevations within it, and this difference was seen as the final bias of the corresponding cell.

The final posted DEM is a composite of Greenland DEMs with different resolutions, so we also compared the elevation differences between the ICESat-2 DEM and IceBridge data of grid cells originated from 500m, 1km (not covered by 500m DEM) and 2km (not covered by 500m and 1km DEMs), respectively (Table 3) as the method above.

Table 3: Elevation differences between the ICESat-2 DEM under different DEM resolutions and IceBridge data.

DEM resolution (grid numbers)	MED(m)	MD(m)	MAD(m)	STD(m)	RMSE(m)	R
500m (11186)	-0.09	-0.16	0.60	2.55	2.55	0.9999
1km (6903)	-0.01	-0.04	0.71	2.81	2.81	0.9999
2km (8453)	-1.37	-1.78	2.52	6.34	6.59	0.9998

The results show that the DEM under 500m and 1km resolutions exhibit higher performances than that of 2 km-resolution DEM, and all biases of the three resolutions are smaller than the interpolation error.

3. Please rewrite the Method part in Page 6, Line 164-173, which is different to understand. When the ICESat-2 data were gridded to fine resolution (i.e. 500 m), there would be many gaps. These gaps will be filled with values from coarse-grid data (i.e. 1 km or 2 km)?

Responses: We rewrote the Method part as follows.

Firstly, Greenland DEM in four resolutions (500 m, 1 km, 2 km, and 5 km) were acquired by the spatiotemporal model fit process. However, these four types of DEM all include voids area thus we need to incorporate them to obtain final Greenland DEM results with the minimal gaps. We used Greenland DEM with 500 m resolution as our first DEM source. Afterwards, Greenland DEMs with 1 km, 2 km, and 5 km resolution were resampled to 500m by applying a bilinear method to fill the gaps in this DEM and the finer resolution as our first option.

“We set the minimum number of grid points to 10 and the minimum timestamp to 2

months ...” ? What does this sentence mean and how the values of 10 and 2 were determined? “In addition, we introduced thresholds to remove outliers, which are RMSE⩾10 m, the uncertainty of elevation change ⩾10 m ...” Please clarify how these thresholds were calculated?

Responses: The minimum number of points in the grid is 7, because the quadratic function based on the local surface terrain used in the text has 7 unknowns. We set the minimum number of points as 10 to ensure the quality of the least square fitting. The minimum number of months is 2 months is also used to make sure the model fit can derive a result. If there is only one month's data in one grid, the fitting equation will have an infinite number of solutions.

We assumed that the maximum elevation change is 10 m/yr and its uncertainty is impossible to exceed 0.4 m/yr as Slater et al. (2018). Furthermore, we assumed that DEM uncertainty is less than 10 m and the maximum RMSE in each grid is 10 m. After this filter procedure, the elevation range is feasible since it is within the elevation range of published Greenland DEM products.

The above statement has also been added into the manuscript.

References: Slater T, Shepherd A, McMillan M, et al. A new digital elevation model of Antarctica derived from CryoSat-2 altimetry. The Cryosphere, 2018, 12(4): 1551-1562.

4. Please rewrite the conclusions in Section 5.2 and Section 6. Due to time discrepancy between different DEM products, I don’t think it is possible to validate ICESat/GLAS DEM (2003~2005), ArcticDEM (2015~2018), TanDEM (2011~2014), CryoSat-2 DEM (2011~2014) using IceBridge data acquired in May 2019 and current results can support the conclusion that the ICESat-2 DEM showed significant improvements in accuracy compared with other altimeter-derived DEMs (in Page 1 Line 20~25). If possible, I suggest selecting areas with little elevation changes and doing the comparison.

Responses: We are sorry that our statement caused misunderstanding.

The data to evaluate other DEMs are the spatiotemporally matched IceBridge data. The IceBridge data to evaluate ArcticDEM were during 2015~2018, TanDEM during 2011~2014, CryoSat-2 DEM during 2011~2014, and the IceBridge data to evaluate ICESat/GLAS DEM were from 2009 since no data can be found in 2003~2005, so we used the data from the nearest year instead.

As you suggest, we selected areas with little elevation changes (-0.05~0.05 m/yr) (Smith et al., 2020) and did a further comparison.

DEM (grid numbers)	MED(m)	MD(m)	MAD(m)	STD(m)	RMSE(m)	R
ICESat-2 DEM (15983)	-0.20	-0.43	0.74	3.05	3.08	0.9999
ICESat DEM (6903)	0.63	0.35	1.10	4.15	4.16	0.9999
CryoSat-2 DEM (27268)	-0.63	0.87	1.42	6.05	6.11	0.9999

500 m ArcticDEM (54235)	-0.14	0.04	0.77	2.19	2.19	0.9999
1 km ArcticDEM (25675)	-0.04	0.06	0.82	2.67	2.67	0.9999
TanDEM (50656)	-4.26	-4.43	4.26	1.97	4.85	0.9999

The conclusion still stands that the ICESat-2 DEM showed significant improvements in accuracy compared with other altimeter-derived DEMs in areas with little elevation changes. The performance is also comparable to the stereo-photogrammetry-derived DEMs and is better than TanDEM.

The above statement has also been added into the manuscript.

Reference: Smith, B., Fricker, H. A., Gardner, A. S., et al. Pervasive ice sheet mass loss reflects competing ocean and atmosphere processes, Science, 368, 1239-+, https://doi.org/10.1126/science.aaz5845, 2020.

5. Since the ICESat-2 data is available from 2018 to present, two years' DEM products could be generated and compared. Otherwise, the specific time should be added to the title, for example, "A new Greenland digital elevation model derived from ICESat-2 during 2018-2019".

Responses: Accept and revised.

General comments:

Page 2 Line 37: "The previously published Greenland DEM dates back to the 1980s ...". "previously" would be "first", since "previously published" would have several DEM products?

Responses: Accept and revised.

Page 2 Line 38-40: "However, the data acquisition was limited by the low-visibility contrast between snow and ice surfaces (Noh and Howat, 2015), which introduced large time uncertainty into the DEM." How the low-visibility contrast introduced large time uncertainty. Please clarify.

Responses: We meant the low-visibility contrast may introduce large elevation uncertainty here. We rewrote the sentence as 'However, the low-visibility contrast between snow and ice surfaces may affect the radiometric and geometric quality of stereoscopic DEMs (Noh and Howat, 2015), which may introduce considerable uncertainty to the elevation.'

Page 3 Line 78-79: "IceBridge data were used to evaluate the accuracy for all of Greenland and for different basins."

According to Figure 1 in Page 16, the IceBridge data didn't coverage all the Greenland, please rewrite this sentence.

Responses: We rewrote this sentence to 'The overall accuracy of ICESat-2 DEM was evaluated by comparing to the spatiotemporally matched IceBridge data.'.

Page 3 Line 91-92: "However, for strong and weak beams in the ATL06 product, both beams in one pair show similar performance, with a median difference of -0.08 cm and -0.13 cm for strong beam2 and weak beam1"

The statement is confusing. "a median difference", compared with what? The results is for strong beam2 and weak beam1, what about the other beams? Please clarify.

Responses: The median difference is compared with contemporaneous IceBridge data. The median difference between strong beam4 and weak beam3 are -0.07m and -0.08m, and the median differences of the strong beam6 and the weak beam5 are the same, -0.03m. Beam2 and beam1 have the largest difference.

We also concluded the result in the text to 'Brunt et al. (2019) compared the elevation of ICESat-2 ATL06 product and GPS data, and found that the accuracy differences of strong and weak beams are less than 2cm. Shen et al. (2021) compared ICESat-2 ATL06 product with IceBridge data under complex terrain, and the result indicated that the height difference between them is also trivial. Hence, we included weak beams to increase spatial coverage and data point utilization due to no systematic errors were found in strong and weak beams in ICESat-2 elevation measurements.' to clarify the statement.

Reference:

Brunt, K. M., Neumann, T. A., Smith, B. E. (2019). Assessment of ICESat-2 ice sheet surface heights, based on comparisons over the interior of the Antarctic ice sheet. Geophysical Research Letters, 46, 13,072–13,078. https://doi.org/10.1029/2019GL084886.

Shen, X. Y., Ke, C. Q., Yu, X. N., et al. Int. J. Remote Sens., 42, 2556-2573, https://doi.org/10.1080/01431161.2020.1856962, 2021.

Page 4 Line 107-112, what do α, β, αs,n, αw,e, β0 stand for? Please clarify.

Responses: The calculation methods of slope and aspect have been deleted as the suggestion of reviewer#2, the detailed calculation can be referred from Shen et al. (2021). α is the slope, β is the aspect, $\alpha_{s,n}$ is the south-to-north slope, $\alpha_{w,e}$ is the west-to-east slope, β_0 stands for the aspect in degree value in the original text.

Reference: Shen, X. Y., Ke, C. Q., Yu, X. N., et al. Int. J. Remote Sens., 42, 2556-2573, https://doi.org/10.1080/01431161.2020.1856962, 2021.

Page 5 Line 145-150, what does h, a0 to a4 stand for? Please clarify how to get a0 to a4 and dh/dt.

Responses: h_i means the elevation of each ICESat-2 footprint in one grid, h means the modelled elevation of the grid. a_0 to a_4 stand for surface elevation fluctuations (the fitting coefficients of a two-dimensional surface) and term t stands for seasonal changes.

All the coefficients were retrieved from an iterative least-squares fit to the observations in each grid. t is the month difference between May 2019 and ICESat-2 acquisition time, which adds a term of time, so the monthly elevation change can be derived.

The above statement has also been added into the manuscript.