We thank the reviewer for the feedback, we have addressed all the comments here, point by point responses to the comments are listed in BLUE.

This manuscript generates a 500 m resolution DEM of Antarctica based on the ICESat-2 data from November 2018 to November 2019 using a spatio-temporal fitting approach. The authors validated the DEM using IceBridge airborne altimetry data and GNSS ground measurements, and also compared it with six other published Antarctic DEMs. Although the results show that the accuracy of this DEM is very superior, I am doubtful about this result.

General Comments:
It is a good attempt to build an Antarctic DEM dataset based on ICESat-2 altimetry data, and Antarctic DEM is important for the study of Antarctic ice sheet changes. ICESat-2 satellite can indeed provide very high resolution and high accuracy ice sheet elevation data and has great potential to be a reliable data source for building Antarctic DEM. However, unfortunately, the dataset was not completely utilized by this manuscript.

We thank the reviewer for the helpful suggestions, we have revised the manuscript accordingly and the details are listed below. Here we summarize the major revision in the revised manuscript:

According to the reviewers, additional filters (a 3-standard-deviation filter and a median filter) have been applied in the generated DEM to improve the DEM performance. The new DEM was also evaluated by comparing to the OIB and GNSS data, similar performances can be found (as listed in the Tables below). In particular, to account for the temporal difference between the DEM and OIB/GNSS data, when performing the comparisons we adjusted the ICESat-2 DEM elevations for the surface elevation changes between the acquisition periods of these two data. The adjustments were calculated by using the trend values derived from Smith et al. (2020) and we assumed the constant elevation change rates, these were applied for the DEM values in the locations of OIB/GNSS measurements. The related text, figures and tables have been accordingly revised, the same conclusions are derived.

The updated DEM map (including uncertainty map) can be downloaded from Google drive at https://drive.google.com/drive/folders/1h0-QxAkjGMSc-eqlBBigiqvgp0k-8iIB?usp=sharing at this stage, and we will replace the previous revision in the data storage (i.e., National Tibetan Plateau Data Center, Institute of Tibetan Plateau Research, Chinese Academy of Sciences) after the manuscript revision.

Table 4 (previous Table 3). Comparisons between the ICESat-2 DEM and OIB airborne elevation measurements (including data in areas of low elevation change from 2009 to 2017 and data in the Antarctica from 2018 to 2019) in observed and interpolated areas for individual regions (i.e., the ice sheet and ice shelves). MeD: median deviation, MeAD: median absolute deviation, SD: standard deviation, RMSD: root-mean-square deviation.

	Region	MeD (m)	MeAD (m)	SD (m)	RMSD (m)	Number of used OIB measurement points
Observed	Ice sheet	-0.17	1.21	9.25	9.26	3589087

	Ice shelves	0.59	2.53	14.07	14.09	191754
	Total	-0.15	1.26	9.56	9.57	3780841
Interpolated	Ice sheet	-0.52	2.63	13.30	13.36	1237416
	Ice shelves	0.44	3.00	15.16	15.21	185613
	Total	-0.41	2.67	13.58	13.62	1423029
Overall	Ice sheet	-0.22	1.47	10.44	10.47	4826503
	Ice shelves	0.53	2.75	14.62	14.65	377367
	Total	-0.19	1.54	10.81	10.83	5203870

Table 7 (previous Table 6). Comparisons between the ICESat-2 DEM, ICESat DEM, ICESat/ERS-1 DEM, Helm CryoSat-2 DEM, Slater CryoSat-2 DEM, REMA DEM, TanDEM PolarDEM and GNSS elevation data in areas of low elevation change from 2001 to 2015.

	MeD (m)	MeAD (m)	SD (m)	RMSD (m)	Number of used GNSS measurement points
ICESat-2 DEM	0.02	0.50	1.59	1.60	
ICESat DEM	-3.79	4.30	10.99	13.10	
ICESat/ERS-1 DEM	-0.75	1.02	2.22	2.32	
Helm CryoSat-2 DEM	0.16	0.89	2.84	2.92	488963
Slater CryoSat-2 DEM	-0.12	0.61	2.41	2.43	
REMA DEM	0.06	0.30	0.78	0.78	
TanDEM PolarDEM	-4.03	4.03	1.52	4.34	

Other specific comments

First of all, there is no innovation in the method study as the spatio-temporal method was referred from Slater et al. (2018). On the one hand, although Slater et al. used this method to build a superior performance Antarctic DEM based on data from the radar altimetry satellite CryoSat-2, the authors' transposition of this method to the data processing of the laser altimetry satellite ICESat-2 may create unknown uncertainties. On the other hand, I consider that using the altimetry data with only a time span of 1 year cannot show the priority of the spatio-temporal fitting model, and can cause fitting errors due to the limited data density and spatial distribution. In fact, this is also reflected in the manuscript, where only 46% of the grids in the 500m resolution DEM claimed by the authors are directly generated by fitting sampling points within the 500m grids, with other gaps either obtained by resampling the grids at low resolution or by kriging interpolation.

Both the elevation measurement data are obtained from the CryoSat-2 radar altimeter and ICESat-2 laser altimeter, hence the kind of input data for spatio-temporal fitting method in our study and Slater et al. (2018) are the same. Additionally, as the CryoSat-2 radar signals may penetrate the snow layer, the elevation measurements from ICESat-2 tend to have less uncertainty than those from CryoSat-2 and ICESat-2 is thus expected to have better performance. Hence, we think that the spatio-temporal method can also be used for the laser altimeter data.

We agree that the spatio-temporal fitting method may be more appropriate for longer time series of altimeter data. However, if this method can still separate temporal elevation changes with just one year of data, it still can be used for DEM generation. Hereafter we provide the map of elevation change rate estimated from this study, we also provide the estimation result from 2003 to 2019 in Smith et al. (2020) for a comparison. Overall, considering the time difference similar elevation change patterns can be found between the two figures. For example, larger elevation decreases can be found in the margin of West Antarctica, obvious elevation increases can be found in the interior of West Antarctica (red cycles in the figure). The elevation change pattern based on one-year ICESat-2 data is reasonable, which indicates that one year of data can give a reliable elevation change map and the elevation estimation is thus reliable. This may due to the much higher measurements density and accuracy of ICESat-2 than previous altimeters.

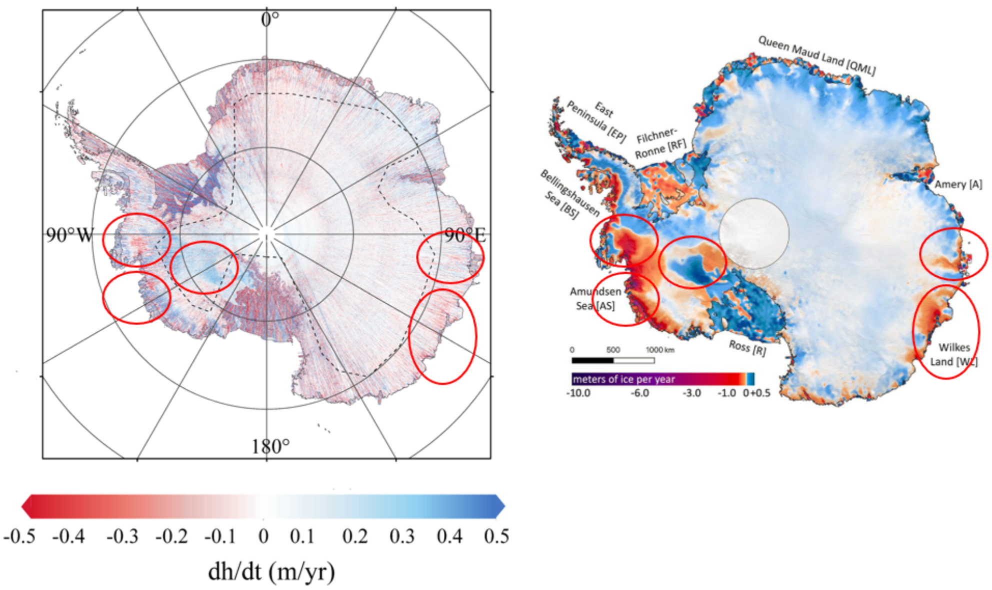

Figure. Map of elevation change rate in Antarctica derived from one year of ICESat-2 data in this study (left) and map of elevation change rate in Antarctica from 2003 to 2019 in Smith et al. (2020) (right).

One-year of satellite altimeter data have also been used to generate the DEM for Antarctica in previous studies. In Helm et al. (2014), one-year of CryoSat-2 data were used for the DEM generation. The DEM is in the spatial resolution of 1 km and the gaps were filled by using the ordinary kriging interpolation (also a series of processing scheme was included), a quite good performance can be found when comparing to the ICESat elevation data. ICESat-2 has much denser and larger coverage than CryoSat-2, hence it is also reasonable to derive the Antarctic DEM by using one-year of ICESat-2 data considering the performance of one-year CryoSat-2 data. In addition, approximately 4.69×10^9 ICESat-2 measurement points from November 2018 to November 2019 were used in this study, while 2.5×10^8 CryoSat-2 measurement points from July 2010 to July 2016 were used in Salter et al. (2018). Considering this, although only one year of ICESat-2 data were used the data density is still larger than seven years of CryoSat-2 data.

The resolutions of grid cells (i.e., 500 m and 1 km) are appropriate for the used ICESat-2 data, it is possible for a quadratic form to model the topography at these scales and smaller elevation residuals can be found than using a simple linear fit (Flament and Remy, 2012). Due to the coverage of used ICESat-2 data (one year of data), we firstly generate the DEMs in 500 m and 1 km grid cells and approximately 74% of Antarctica can be covered, the remaining observation gaps are interpolated using the ordinary kriging method; in Slater et al. (2018) a 60% coverage can be found for his finest 1km grid DEM by using seven years of CryoSat-2 data. For the 1 km grid DEMs from this study and Slater et al. (2018), although the time series are different similar data coverage can be found.

In addition, ICESat-2 DEM has a comparable performance to other DEMs by comparing to the same airborne and GNSS data sets (after the correction for effect of the temporal difference between the DEM and OIB/GNSS data), which also proves the feasibility of the data and method.

Considering the data density/coverage, method performance and DEM accuracy, the DEM generated by using spatio-temporal fitting method from one-year of ICESat-2 data is still reasonable and reliable.

The related statements about the reliability of using one-year of ICESat-2 data have also been added into the revised manuscript (i.e., subsection 2.4.1):
'*… Additionally, the performance of the surface fit method also depends on the timespan of the input data, that is to say, it should be noted that whether one-year of ICESat-2 data can be used to obtain a satisfied fitting performance. Here we find that the elevation-change rate map based on one-year ICESat-2 data (i.e., a_5 in Eq.1) has a similar pattern with that from Smith et al. (2020), which estimated the elevation-change rate from 2003 to 2019 based on ICESat and ICESat-2 data, indicating that one-year of data can also provide the reasonable elevation change rates and thus the surface fit method used here is reliable.*'

The related statements about the choice of DEM resolution and details about the spatial coverage have also been listed in subsection 2.4.2 in the manuscript.

References:
Smith B, Fricker H A, Gardner A S, et al. Pervasive ice sheet mass loss reflects competing ocean and atmosphere processes. Science, 2020, 368(6496): 1239-1242.
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.
Helm, V., Humbert, A., and Miller, H.: Elevation and elevation change of Greenland and Antarctica derived from CryoSat-2, The Cryosphere, 8, 1539-1559, https://doi.org/ 10.5194/tc-8-1539-2014, 2014.

Secondly, I have serious doubts about the reliability of this Antarctic DEM dataset, and although the authors use some measured data to validate it, I do not think this validation method is reliable. Although these variations are neglected in areas with small elevation changes in the interior of the ice cap, I do not agree that it is reasonable to use OIB and GNSS data with large time differences to assess the DEM accuracy. In addition, it is not representative of the accuracy of the whole DEM, limited by the amount and distribution of the validation data. Of course, this is due to the limitation of obtaining large-scale field measurement data. However, it cannot be arbitrarily claimed that the accuracy of DEM under such validation conditions is better than the results of other scholars.

In order to provide a relatively comprehensive and robust evaluation of ICESat-2 DEM, all OIB and GNSS data in areas of low elevation change are used. The CryoSay-2 Low Rate Mode (which was designed for flat ice sheet interior measurements) mask is used to extract the regions of low elevation change. CryoSat Geographical Mode Mask (v 4.0, updated in 19 August - 26 August 2019) at https://earth.esa.int/eogateway/news/cryosat-geographical-mode-mask-4-0-released is used here.

One problem may be caused when using OIB and GNSS data with time differences to assess the DEM accuracy, that is the 'real' elevations may be variable during the timespan. As we can find in areas of low elevation change, the elevation change rate is about **-0.0074±0.0821 m/yr** from 2003 to 2019, in these areas the effect of the elevation change on the DEM evaluation can be ignored. However, we do agree that the effect of the time difference between OIB/GNSS data and ICESat-2 DEM should be considered. In the revised manuscript, we adjust the ICESat-2 DEM elevations for the surface elevation changes between the acquisition periods of these two data and we assume the constant elevation change rates. The adjustments are calculated by using the trend values are derived from Smith et al. (2020) and applied for the DEM values in the locations of OIB/GNSS measurements. The related text, figures and tables have been revised, but the same conclusions are derived (according to the Tables in the very beginning).

This part has also been added in Section 2.2 in the revised text: '*Although OIB and GNSS data in the low elevation-change areas and OIB data with small time-difference (< one year) comparing to ICESat-2 DEM are used for DEM evaluation, the effect of time difference between the DEM and evaluation data still needs to be considered. Here, we adjust the changes of ICESat-2 DEM elevation values which occur during the time difference between these two data, the trend values are derived from Smith et al. (2020) and we assume the constant elevation change rates, the corresponding adjustments are calculated and applied for the DEM values in the locations of OIB/GNSS measurements before comparisons.*'.

Besides, in the revised manuscript we mainly focus on the evaluation of ICESat-2 DEM, construct a general comparison to other DEMs and avoid the expression about the accuracy rank. In Section 4 in the revised text, we also add a paragraph to emphasize it:
'*… It should be noted that, the spatio-temporal coverages of used OIB and GNSS data are limited here, and they cannot provide an unbiased evaluation for ICESat-2 DEM and other DEMs. Hence the comparisons above only give a general reference for their performances and cannot be used as the quantitative accuracy evaluation.*'.

In addition, from the perspective of manuscript writing, this manuscript is well structured and the language is more fluent, but there are some places where the expression is not very clear and there are also a large number of obvious typographical errors. For example, Fig. 1b and Fig. 1c are not seen in Fig. 1, but they appear in lines 105 and 108, respectively; in line 305, the description of the comparison of other DEMs should be discussed in Section 4, which seems very confusing here; in Table 6. it should be 'Number of used GNSS measurement points' instead of 'Number of used OIB measurement points', etc.

We have carefully checked the whole manuscript, corrected the related errors and revised the vague expressions.

For Fig. 10 (line 305 in previous manuscript) we only focus on the evaluation of ICESat-2 DEM now: '*In the ice sheet interior where surface slopes are small (Fig. 10a), elevation differences of approximately 5 m can be found (**the median elevation differences for ICESat-2 DEM is -0.13±0.19 m**). The elevation differences are further reduced when surface slope become smaller. While at the Pine Island Glacier where surface slopes are large (Fig. 10b), elevation differences of approximately 20 m can be found in the undulated terrains (**the median elevation differences for ICESat-2 DEM is -0.01±4.58 m**). Overall, ICESat-2 DEM has better performances in the flat regions than steep areas. Regions of low surface slope represent the majority of Antarctic ice sheet, hence most elevations from ICESat-2 DEM have smaller elevation biases.*'. The description of the comparisons of other DEMs has been removed.

In fact, I have also seen this manuscript in the discussion forum of *The Cryosphere* last year, and this does not seem to be too much changed from the previous manuscript. Moreover, another article by the authors using the same approach applied to Greenland has been published in *ESSD* (Fan et al. 2022), and the two manuscripts are similar in approach and writing style, and I do not think it is worth publishing a similar work again.
In conclusion, I think the manuscript has no innovations in the DEM generation method and the dataset is not reliable, and its validation data are not enough to support the authors' conclusion, so it is not recommended for publication.

References
Fan, Y., Ke, C.-Q., and Shen, X.: A new Greenland digital elevation model derived from ICESat-2 during 2018–2019, Earth Syst. Sci. Data, 14, 781–794, https://doi.org/10.5194/essd-14-781-2022, 2022.
Slater, T., Shepherd, A., McMillan, M., Muir, A., Gilbert, L., Hogg, A. E., Konrad, H., and Parrinello, T.: A new digital elevation model of Antarctica derived from CryoSat-2 altimetry, The Cryosphere, 12, 1551–1562, https://doi.org/10.5194/tc-12-1551-2018, 2018.

We made a major revision for the manuscript according to the comments from three reviewers of *The Cryosphere*, we have regenerated and reevaluated the DEM by comparing to the OIB/GNSS data. The presented DEM and evaluation results have been greatly changed, the manuscript structure is the same and hence it seems like that there are no too much changes.

The same method in Slater et al. (2018) is used here to generate the DEM from ICESat-2 data, in the comments above we have provided the reasons why we choose this method and proved that one-year of data can still be used for DEM generation. More importantly, our result demonstrates that the ICESat-2 DEM can be provided in a sustainable way, i.e., the ICESat-2 DEM can be updated annually and thus accumulated on an annual base, which has large application potential for Antarctica especially under the warm climate. Additionally, reasonable elevation-change rate can also be obtained when deriving this DEM, which can provide an additional reference for ice topography and mass balance estimation. Hence, in Section 4 we add a paragraph to point out the differentiation between our work and other studies, i.e., the special contribution of our work: '*… Comparing to other DEMs, elevation change rate can be obtained when deriving the ICESat-2 DEM, which provides an additional reference for ice topography and mass balance estimation. Additionally, in previous studies several years of altimeter data are needed to derive the DEM in Antarctica. Due to the high-density measurements of ICESat-2, 13 months of ICESat-2 data can be used to generate a DEM for Antarctica and the performance is comparable to other DEMs, indicating that the ICESat-2 DEM can be updated annually. This study demonstrates the feasibility and reliability of using one-year ICESat-2 data to derive the Antarctic DEM, provides a reference for the processing scheme of DEM (e.g., in higher resolution, regularly updated) based on ICESat-2 in future.*'.

Although the structure of this paper has some similarities to Fan et al. (2022), it still has many differences, e.g., the comparison and choice of DEM resolutions, DEM postprocessing method, DEM uncertainty estimation method, DEM evaluation method (including slope-related and along-track comparisons), presentment of detailed maps of DEM, potential applications and advantages of this dataset, these can provide a potential reference for the generated DEM in future studies.

Our paper is a kind of 'Data description paper', its aim is to introduce the presented Antarctic DEM from ICESat-2 data, hence we think the dataset itself and the significance of this dataset/work to the scientific community are more important here. The related validation approach and statements have been changed/revised accordingly to provide reasonable evaluation and expressions. Similar evaluation result can also be found for our ICESat-2 DEM when using the new validation approaches (as shown in the above comments), hence this DEM is still reliable. More importantly, as you mentioned in the very beginning, Antarctic DEM is essential for the study of Antarctic ice sheet changes. The elevations of high accuracy and ability of annual update make the ICESat-2 DEM a special addition to the existing Antarctic DEM groups, and it can be further used for other scientific applications in Antarctica, and thus we still think that this paper still suits the scope of *ESSD*.