Response to Editor

We would like to thank Editor Dr. Francesca Pellicciotti for reviewing our revised manuscript as well as the responses. In the following, we address all comments point-by-point according to editor's comments.

Thank you very much for your revised manuscript and response to the reviewers. The paper is much improved, and I thank you for your efforts. I still see few problematic issues, however, and I am sending the manuscript to the reviewers again for a second review.

I feel that some of your statements in the responses would need some more evidence to back them, e.g .the reply to Reviewer 1 comment on the accuracy of the high resolution dataset is not entirely convincing; I am not sure I understand what you did in response to the Reviewer 2 comment on the two criteria you used to define EDW; and finally the English still needs major improvements (see e.g. line 224, 232; new lines 272-275; 312-315; etc).

-Answer: Thanks a lot for the comments. Firstly, about the accuracy of the data set, we added more information on the method section according to Referee 1's comment. According to the authors' previous studies, ERA-Interim has a high degree of credibility. In order to enhance credibility and persuasiveness, we collected more research cases from other scholars, especially the evaluation of ERA-Interim over China. For example, Hairiguli et al (2019) concluded that the ERA-Interim could capture the inter-annual variations of monthly mean temperature in the CTM from via comparing with 45 observation sites from 1984 to 2016. Bai et al (2013) found that ERA-Interim temperature data is better than NCEP/NCAR data based on a comparison with 9 observation sites in the CTM from 2004 to 2006.

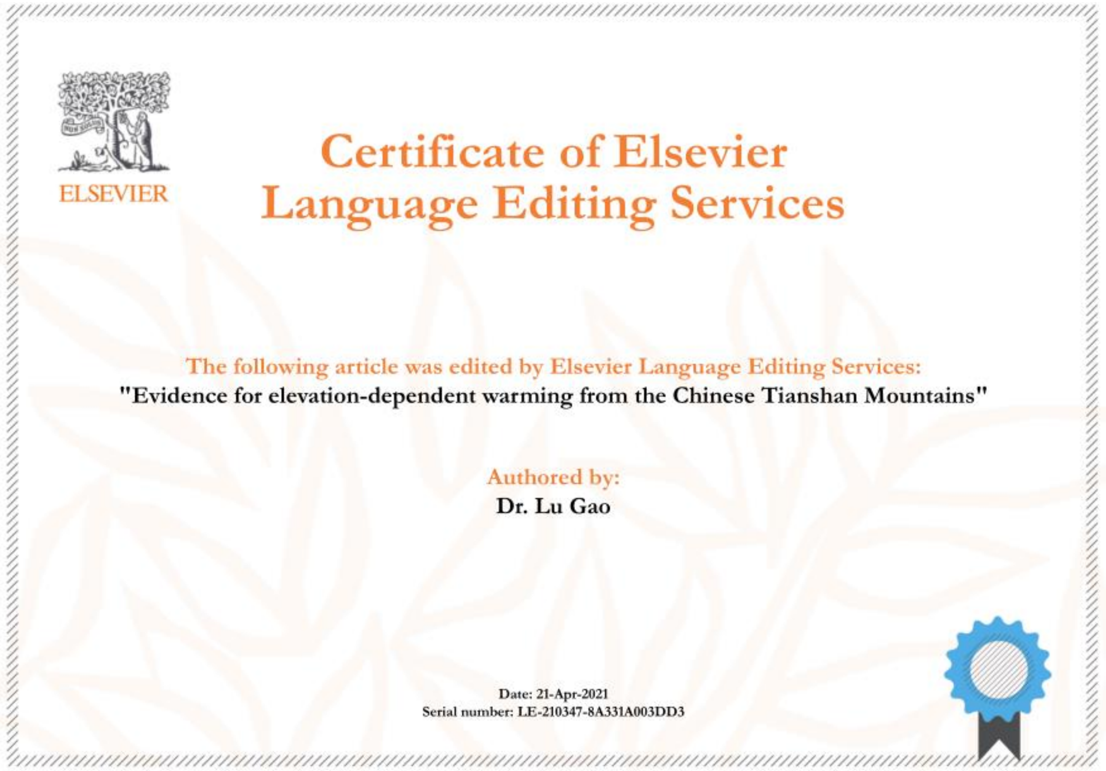
We understand the concerns of reviewers, especially on the data accuracy.

We still want to explain that most of the model data (GCMs, reanalysis) have errors, and a large part of the errors are systematic biases. After the systematic biases are effectively eliminated, the corrected model data has a good ability to capture the long-term climate change trend. The core of EDW refers to the increasing trend of temperature within a certain time period (generally longer than 30 years). Thus, the model data as well as the corrected data is still the first choice for climate analysis.

We have been working hard to collect more high-resolution data for validation, but with little success. Other gridded data sets (e.g. CRU at 0.5 degree) do not meet the validation requirements (because the CTMD is at 1 km grid). Therefore, this is the result we can get at the present stage. We thank the referee’s consideration.

Secondly, about the EDW definition, we tried to clarify in the revision. In the review paper published by Rangwala and Miller (2012) and Mountain Research Initiative EDW Working Group (2015), they claimed that the regional warming amplification and altitude warming amplification are the two fundamental questions for the EDW. It means that these two most important characteristics need to be detected, respectively. Furthermore, they also concluded that the EDW is existent in some typical mountains (e.g. Alps) because the altitude warming amplification can be detected by observation and climate models. However, the regional warming amplification is still difficult to detect because of limited observations at global scale. Therefore, from our understanding, the EDW could be determined once the regional warming amplification or altitude warming amplification could be detected. But it should be pointed out that the regional warming amplification is difficult to judge because of limited observations. Therefore, in this study, the regional warming amplification is detected by comparing the CTM with the continental China, rather than the global. We revised this part in the revision.

Thirdly, the manuscript for language, grammar, clarity, readability, and an appropriate tone are revised by a native speaker via the Elsevier language editing service (https://webshop.elsevier.com/).



ELSEVIER

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The following article was edited by Elsevier Language Editing Services:
"Evidence for elevation-dependent warming from the Chinese Tianshan Mountains"

Authored by:
Dr. Lu Gao

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Last but not least, we admit that the CTMD is not so perfect that should be further validated by more observations. But we still believe this is a useful and meaningful attempt to reveal the potential EDW phenomenon in the arid high mountains.

In response to a comment by Reviewer 2 you state that “We plan to update a more high resolution data V2.0 (100m, 6-hourly) since the CTMD V1.0 that released in 2018.” Is this new dataset available now and did you use or will you be able to use it?

-Answer: Thanks a lot for the comments. Yes, we are working on the CTMD V2.0 for a long time. Here we want to briefly introduce the methodology on this data. The influence of altitude on temperature is basically unchanged at a below 1km spatial resolution. On the contrary, slope and aspect become the dominant factors. Thus, the CTMD V1.0 solves the problem of the influence of altitude on temperature. But CTMD V1.0 has a relative poor ability to reflect the temperature changes at micro-terrains. Thus, the CTMD V2.0 tends to further consider the impact of the micro-topographic factors (slope and aspect) on the air temperature. The CTMD spatial resolution is upgraded from 1km to 100m grid via the model as follows:

$$T_{100} = T_{1km} \frac{\cos i}{\cos z} \qquad (1)$$

$$\cos i = \cos a \cos z + \sin a \sin z \cos(r - b) \qquad (2)$$

where, T_{100} is the CTMD V2.0 temperature at 100 m grid, and T_{1km} is the CTMD V1.0 temperature at 1km grid. i is the angle between the normal line of earth's surface and sun's rays; a is the slope; z is the solar zenith angle; r is the sun's azimuth angle, and b is the slope. Previous studies always used fixed zenith angles and azimuth angles, ignoring the diurnal changes of temperature. In the CTMD V2.0, z and r is calculated according to the earth parameters (e.g. earth radius) and the time point of the data set (00, 06, 12, 18 UTC). However, because of the COVID-19, this work is significantly affected and it lags behind our schedule. An important and necessary work is that we must go to the field to collect ground observation data (cooperation with the Glacier Observatory of the Chinese Academy of Sciences) to verify the data set. We hope to release this data set no later than next spring.

References:

Hairiguli, N., Yusufujiang, R., Madiniyati, D., and Roukeyamu, A.: Adaptability Analysis of ERA-Interim and GHCN-CAM Reanalyzed Data Temperature Values in Tianshan Mountains Area，China，Mountain Research, 37(4): 613-621, 2019. (In Chinese with English abstract)

Bai, L., Wang, W., Yao, Y., Ma, J., and Li, L.: Reliability of NCEP/NCAR and ERA-Interim Reanalysis Data on Tianshan Mountainous Area, Desert and

Oasis Meteorology, 7(6): 51-56, 2013. (In Chinese with English abstract)

Mountain Research Initiative EDW Working Group: Elevation-dependent warming in mountain regions of the world, Nature Climate Change, 5, 424-430, 2015.

Rangwala, I., and Miller, J. R.: Climate change in mountains: a review of elevation-dependent warming and its possible causes, Climatic Change, 114, 527-547, 2012.

Response to Referee 1

We would like to thank anonymous Referee 1 for reviewing our manuscript. These professional comments are really helpful for improving the manuscript. In the following, we address all comments point-by-point according to referee's comments.

This study intends to reveal EDW in the Chinese Tianshan Mountains using a high resolution data that are developed in the previous study based on ERA-I data in combination with topographic correction method. Despite merits such as clear structure and better writing to be easy to follow, I have three comments in the following:

1. My major concern is the accuracy of data used. This paper does not do a detailed introduce to the high-resolution data, which results in that I cannot evaluate its accuracy or reliability. After a look at the reference provided, it shows that the high resolution data are based on ERA-I reanalysis. ERA-I is developed based on model simulation in addition to weather station observations, so it generally has large uncertainties in such a small region, especially for mountainous region. Because ERA-I includes in suit observations at some weather stations, it may be unsurprised there are very seasonable performance for evaluation using observed data from perhaps the same weather stations.

-Answer: Thanks a lot for the comments. The referee pointed out a very important issue on the accuracy of data, which is the foundation of presented study. That is true that we just provided limited information on the data set because we leave more space to EDW analysis. We accept the comment and will add more data set information in the revision.

Here, we would like to introduce the data set briefly. It is true that the data set is produced based on ERA-Interim data and an elevation correction method. We also agree that the uncertainty is large for original ERA-Interim. Our previous studies revealed that there are around 3-4 °C systematic bias from original ERA-Interim (Gao et al., 2014, 2017). Thus, a correction is necessary before local application. The correction approach based on the internal lapse rates derived from ERA-Interim has been proven to be effective in the mountains. Although, there is still a less than 2 °C bias after elevation correction, the warming trends could be captured very well (Gao et al., 2018, Table 1). 24 meteorological stations are applied for data set validation in the CTM from 1979-2013. The averaged trend difference between observation and CTMD is only 0.07 °C $10a^{-1}$ respects to annual and seasonal temperatures. Although the CTMD tends to underestimate the trends for minimum temperatures, we still believe that CTMD is reliable to capture the EDW trend.

Table 1. Trends (°C $10a^{-1}$) of annual and seasonal temperatures over the 24 sites in 1979-2013.

	Annual	Spring	Summer	Autumn	Winter
observation	0.420	0.664	0.432	0.532	0.018
ERA-Interim	0.378	0.659	0.530	0.448	-0.153
correction	0.349	0.638	0.478	0.443	-0.195

Meanwhile, we would like to emphasize that the CTM is not a small mountain region (larger than 350,000 km^2) which only has less than 30 meteorological stations. Most of them are located in the piedmont plains or valleys. Thus, the validation based on limited surface meteorological station may be not objective. We also know that the analysis of future climate change scenarios relies on model data such as GCM outputs, which have large uncertainties. However, the GCM models are still the most powerful tool for climate change analysis, and the trends modeled by the GCM are still credible. Thus, we believe that although ERA-Interim has errors, it has the ability to reveal regional climate changes after elevation correction. Furthermore, ERA-Interim assimilated ground observation data, which can more accurately reflect local climate change.

The referee also raised another very important issue that it is unsurprised about the seasonable performance of ERA-Interim at certain stations. Here, we would like to clarify briefly. The ERA-Interim applied ECMWF Integrated Forecast System (IFS) which could assimilate observations in the model. However, only a very small part of observations was assimilated. 9 of 24 sites were possible assimilated by IFS for ERA-Interim in the CTM according to ECMWF assimilation records (Gao et al., 2018, Table 2). Only 4 sites with long-term observations (more than 30 years) while other 5 sites (less than 15 years) were assimilated. In other words, ERA-Interim is a relative independent data set (considering the ratio of ground stations amount to the whole CTM area). We believe the performance of ERA-Interim sometimes is “surprised” in such a complex terrains and it is reliable for regional climate change detection.

Table 2. Possible assimilated sites in the CTM in ERA-Interim.

Name	WMO id	starting date	ending date
Jinghe	51334	1979-06-21	1993-01-21
Qitai	51379	1979-06-03	1985-05-20
Yining	51431	1978-12-31	2011-12-31
Urumqi	51463	1978-12-31	2011-12-31
Qijiaojing	51495	1979-04-07	1993-04-24
Turfan	51573	1981-06-30	1984-08-08
Kuche	51644	1978-12-31	2011-12-31
Kuerle	51656	1979-01-03	1994-12-30
Hami	52203	1978-12-31	2011-12-31

2. This paper discusses the mechanism only, if data can be used to reveal some mechanism in the research region, it will be a better progress. The mechanism discussed may be suitable for other regions, but is not always in the case for the research region in the present study.

-Answer: Thanks a lot for the comments. The referee is definitely right that the mechanism is the key issue for EDW. We added the snow cover rate and snow depth data in the analysis, and the relationship between snow and temperature is discussed in the revision. For example:

Deng et al (2019) found that the snow cover rate in the CTM decreased from 2002-2013 at a rate of 0.44%. According to the snow cover rate data from Chen et al (2016) and Deng et al (2019), the maximum snow cover rate always occurred in January, while the minimum snow cover happened in July. We tested the relationship between monthly Tmin, Tmean and Tmax and maximum/minimum snow cover rate for each month in 2002-2013. Figure 8 shows the relationship of temperature and snow cover rate. Only February Tmin has a strong correlation ($R^2=0.302$, $p<0.1$) with the maximum snow cover rate (Fig. 8a). For minimum snow cover rate, Tmax in August has a significant correlation ($R^2=0.256$, $p<0.1$) with it (Fig. 8a). The correlation between temperatures in other months and snow cover rate is not significant.

Based on the snow depth data, the trend is calculated. The annual trend of snow depth over the CTM from 1979-2016 is -0.12 cm 10a^{-1}, which means the snow is accelerated melting. Except January (0.16 cm 10a^{-1}) and February (0.05 cm 10a^{-1}), snow depth decreases in other months ranged from -0.01 to 0.58 cm 10a^{-1}. The snow depth decreases the fastest in March with a rate of -0.58 cm 10a^{-1}, followed by April with a rate of -0.45 cm 10a^{-1}. Thus, spring has the highest decreasing trend of snow depth. However, the temperature trends are most significant in spring and March with respect to Tmin, Tmean and Tmax (Table 3 and 4). The relationship between snow depth and temperature is further investigated in the CTM from 1979-2016 (Table 6). A significant correlation ($p<0.01$) could be found between Tmin and snow depth in March and June. For the couple of Tmean and snow depth, the remarkable correlation ($p<0.01$) also could be found in March, June and August. The significant correlation ($p<0.01$) only could be found in December between Tmax and snow depth (Table 6). In some cold months, for example, November and January, a relative significant correlation ($p<0.05$) can be found between Tmean/Tmax and snow depth. Figure 9 shows the scatter plots of comparison of Tmin and Tmean in March with snow depth. The negative correlation is perspicuous and visible. In general, there is a negative correlation between temperature and snow cover/snow depth (Figs. 8 and 9), which implies that the temperature warming has an effect on the accelerated melting of snow, or the melting of snow affect the temperature warming. The detailed feedback mechanism between snow and temperature needs to be further verified and explored by using more advanced technology and models. In summary, although many hypothetical mechanisms of EDW have received widespread attention, most of them are limited to phenomenon description and qualitative analysis. However, the present study tried to do some preliminary explorations on the mechanism based on limited snow cover and snow depth data.

Table 6. Relationship (R^2) of snow depth (cm) and monthly Tmin, Tmean and Tmax from 1979-2016.

	Tmin	Tmean	Tmax
January	0.021	0.098*	0.109**
February	0.031	0.050	0.103*
March	0.399***	0.400***	0.033
April	0.003	0.076	0.008
May	0.086*	0.104*	0.012
June	0.194***	0.230***	0.095*
July	0.081*	0.108*	0.016
August	0.047	0.242***	0.083*
September	0.001	0.072	0.150**
October	0.010	0.020	0.103*
November	0.051	0.125**	0.151**
December	0.014	0.159**	0.200***

Note: * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

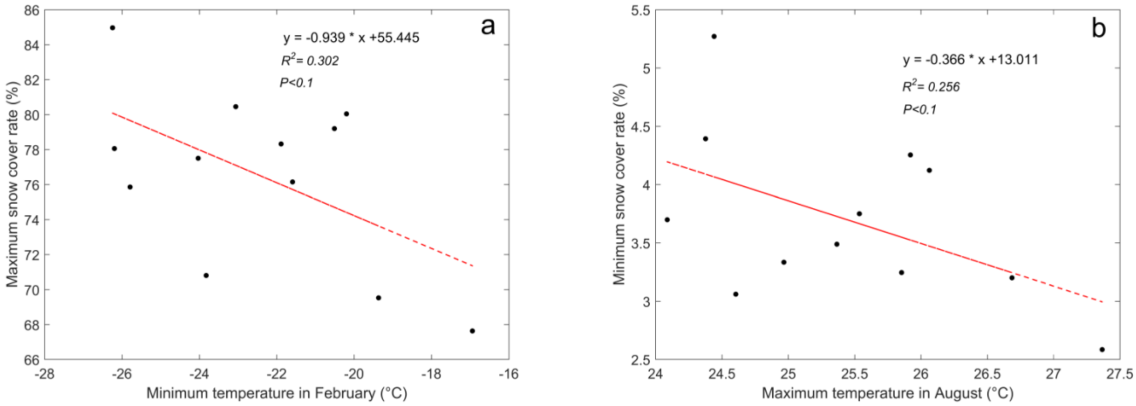

Figure 8: Relationship of temperature and snow cover rate (a) minimum temperature in February vs. maximum snow cover rate and (b) maximum temperature in August vs. minimum snow cover rate from 2002-2013.

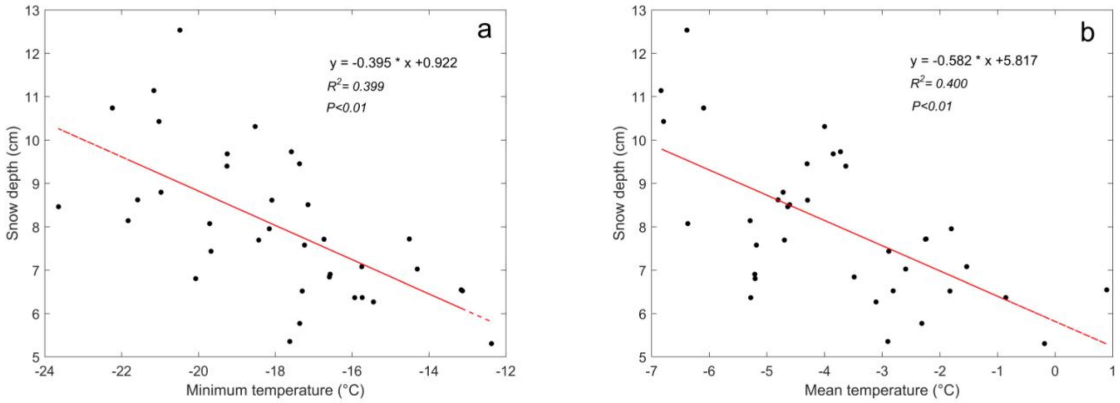

Figure 9: Relationship of snow depth and (a) Tmin in March and (b) Tmean in March from 1979-2016.

3. Some expressions are not very rigorous. Such as Line 83-85, the author say that satellite data have low spatial resolution, which is questionable. Some satellite data with 1 km resolution are the same resolution as data used in this study. The author also say large system errors with satellite data, which needs analyses or references to confirm.

--Answer: Thanks a lot for pointing this out. We agree that some parts are not very rigorous. We checked the full text and revise them in the subsequent revision.

Gao, L., Hao, L., and Chen, X.W.: Evaluation of ERA-interim monthly temperature data over the Tiberan Plateau, Journal of Mountain Science, 11(5): 1154-1168, 2014.

Gao, L., Bernbardt, M., Schulz, K., and Chen, X.W.: Elevation correction of ERA-Interim temperature data in the Tibetan Plateau, International Journal of Climatology, 37(9): 3540-3552, 2017.

Gao, L., Wei, J., Wang, L., Bernhardt, M., Schulz, K., and Chen, X.: A high-resolution air temperature data set for the Chinese Tian Shan in 1979–2016, Earth System Science Data, 10, 2097-2114, 2018.

Response to Referee 2

We would like to thank anonymous Referee 2 for reviewing our manuscript. These constructive comments are very important for us to improve the present manuscript. In the following, we address all comments point-by-point according to referee's comments. The detail responses please see the supplement.

General comments:

This article analyses whether elevation-dependent warming (EDW) is present in the Chinese Tianshan Mountains, both overall and at a regional level. The authors present a compelling case for research into this phenomenon, as increased warming in higher regions may have detrimental effects on glacier melt. EDW is judged based on the criteria of regional warming amplification and altitude warming amplification, and these two criteria are assessed for the entirety of the Chinese Tianshan Mountains on a monthly time scale. Furthermore, spatial differences in EDW are assessed across the mountain range. Overall, the paper is well presented and structured, and the discussion and conclusions of this spatially and temporally complicated problem are interesting. However, there are some issues which I think need to be addressed before publication, most importantly the definition of EDW used in the paper and how it relates to the conclusions reached in the paper, and the suitability of the data set used for this analysis, as highlighted below.

Specific comments:

1. Whole paper: The authors have carefully defined elevation-dependent warming (EDW) immediately in the article, namely that two criteria should be met: regional warming amplification and altitude warming amplification. Section 3.1 concludes that regional warming amplification is only present in

any of the minimum, mean and maximum daily temperatures in the months from February to June. However, in section 3.2, warming amplification with altitude is now described as EDW, for example line 183 “The prevalence of EDW is most significant in December...”. This is then used for the remainder of the paper, especially in the conclusions. The authors should identify the months which satisfy both regional warming and altitude warming amplification, and these months should be set out clearly as the months where EDW is present.

This needs to be altered throughout the paper, and has substantial implications for the conclusions, as I think there are only one or two months which satisfy both conditions.

-Answer: Thanks a lot for the comments. The reviewer pointed a very important issue. After carefully reviewing the literatures again, we have to admit that our previous definition of EDW were a bit arbitrary. To be precise, regional warming amplification and altitude warming amplification are the two basic characteristics (or “fundamental questions” from Rangwala and Miller, 2012) of EDW. In the previous literatures, although there are many discussions on altitude warming amplification in high mountains, no literature clearly states that regional warming amplification is one of criteria for EDW. We revised this part through the whole paper in the revision.

2. Methods/CTMD dataset: I think there should be some discussion of the suitability and limitation of the CTMD dataset for this analysis, given that the paper is reliant on it. Two particular points stand out: o Gao et al., 2018 gives an analysis of the data set compared to a number of stations; however they are all under 3000 m asl. I do appreciate the difficulty of finding high elevations stations, but do the authors have any evidence that this data set is suitable at elevations of 5000 m asl and above? In addition, Gao et al., 2018 also indicates that the lapse rate from ERA-interim (the correction term used to

downscale ERA-Interim to the 1km scale) is steeper than that seen in the observations. It is often the case that the free atmosphere lapse rate is steeper than the near-ground lapse rate of temperature with elevation, and this difference may cause errors in the 1 km data set used in this paper.

Gao et al., 2018 acknowledge that the trends in the ERA-Interim data, and therefore the CTMD, do not always follow those of the observations. For example, in the minimum daily temperature, the trend in the CTMD considerably underestimates that of the observations. It is not clear whether this bias is constant with elevation, which is essential to the results presented in this manuscript.

-Answer: Thanks a lot for the comments. The reviewer raised a challenge issue on the quality of CTMD. We must admit that the credibility of data in high-altitude areas is always a huge challenge. In Gao et al., 2018, we used 24 sites to validate the CTMD. It is true that all the sites are lower than 3000 m. We are looking for reliable observation data all the time to further verify the quality of CTMD. We plan to update a more high resolution data V2.0 (100m, 6-hourly) since the CTMD V1.0 that released in 2018. However, as far as we know, there are only very few automatic weather observation stations between 3000-5000m. The time series of these observational data is always short than 10 years with some data gaps. Meanwhile, we have to clarify that these observations data are difficult to access due to permission issues. Therefore, we only could evaluate the credibility of CTMD based on limited observations. In general, we could conclude that the CTMD has a small large-scale bias because of small large-scale errors of ERA-Interim. Previous studies claimed that the large-scale errors of ERA-Interim are acceptable with respect to long-term trends (Gao et al., 2012; Simmons et al., 2010).

About the lapse rate, the referee is right that the lapse rate from ERA-interim is steeper than the observations. Figure 4 in Gao et al., 2018 has shown that the lapse rates of ERA-Interim are greater than observations from September to December. Generally, the influence of elevation on temperature is basically unchanged at a smaller spatial resolution of 1km, while slope and aspect of the terrain become the dominant factors at hundreds meters. It is true that the free atmosphere lapse rate is steeper than the near-ground lapse rate of temperature because of the different radiation mechanism. To overcome this limitation, the downscaling model used different spatial spans, that is, from the near surface layer (~925hPa) to the free atmosphere (~500hPa). The selection of the lapse rate (such as Γ_{700_925}) for each grid is completely dependent on its altitude, which reflects a larger elevation range as much as possible for a more real temperature lapse rate as possible. In the downscaling model, we used the ERA-Interim 2-m temperature instead of site temperature. Therefore, the downscaling model is completely independent of ground stations. However, we agree that the ERA-Interim lapse rate may be part of the source of error. Meanwhile, it is a challenge to distinguish this error quantitatively from the ERA-Interim model errors.

The referee is right that the trend of minimum temperature in CTMD does not follow that of observations in Gao et al., 2018. The CTMD in Gao et al., 2018 covers a larger area (818126 km^2), which includes such as the plains on the northern slope of the CTM and the basins on the southern slope of CTM. A “Cold Lake” effect may occur within the basin in winter. The lapse rate may be positive rather than negative. For example, the Turfan Basin (below mean sea level) may have a temperature inversion layer in winter. The present study re-defines the Tianshan boundary according to Deng et al (2019). The CTM contains numerous inter-valley basins and oasis. Thus, the trends of minimum temperature in low terrains may be problematic. However, this study focuses on the trend over the whole CTM, and CTMD may not be good enough on the site scale, but it is still representative on the entire region. We added more information on the limitation of CTMD in the revision. For example:

Although, the CTMD was validated by 24 meteorological stations on a daily scale, indicating a high reliability for the climatology trend investigations, the limitations should be fully demonstrated. Whether the lapse rate can accurately reflect the temperature changes at altitudes is worth discussing. For example, the lapse rates of ERA-Interim are greater than observations from September to December, while lapse rate in the free atmosphere is steeper than that near ground because of the different radiation mechanism (Gao et al., 2018a). The lapse rate may be positive rather than negative since the "Cold Lake" effect in winter such as in the Turfan Basin, which may have a temperature inversion layer at night. Under this situation, the downscaling model may be disabled for winter. Therefore, an opposite trend for minimum temperature during winter is captured by the CTMD compared to the slight positive warming trend from 24 sites. Meanwhile, the trend of diurnal temperature range (DTR) is not captured very well by the CTMD in spring and autumn (Gao et al., 2018a). We want to emphasize that the CTMD is only validated by 24 sites, which are mainly in low terrains. The credibility of the CTMD in the high peaks is difficult to evaluate because of few observations exist. However, we believe that the CTMD is still creditable since it could capture the distribution characteristics of temperatures as well as the general warming trends.

3. Table 1 and 2: given the variation over time, it would be useful to know which of these trends is statistically significant.

-Answer: Thanks a lot for pointing this out. We will mark the significance levels with asterisk in Table 3 and 4 in the revision.

Table 3. Annual and seasonal temperature trends (°C 10a^{-1}) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTM			WCC			LCC		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
Spring	0.633 ***	0.522 ***	0.640 ***	0.557 ***	0.513 ***	0.518 ***	0.543 ***	0.498 ***	0.505 ***
Summer	0.441 ***	0.342 ***	0.266 **	0.472 ***	0.388 ***	0.378 ***	0.404 ***	0.336 ***	0.348 ***
Autumn	0.302	0.200 *	0.270	0.551 ***	0.458 ***	0.420 ***	0.506 ***	0.411 ***	0.371 ***
Winter	0.014	-0.085	0.115	0.432 ***	0.361 ***	0.327 ***	0.333 **	0.257	0.211
Annual	0.347 ***	0.245 ***	0.323 ***	0.503 ***	0.430 ***	0.411 ***	0.446 ***	0.376 ***	0.359 ***

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level p<0.1, ** denotes the significance level p<0.05, and ***

denotes the significance level *p*<0.01.

Table 4. Monthly temperature trends (°C 10a^{-1}) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTMD			**WCC**			**LCC**		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
January	-0.133	-0.269	-0.235	0.343 **	0.256	0.212	0.225	0.143	0.102
February	0.313	0.177	**0.605** **	0.558 ***	0.523 ***	0.549 **	0.486 **	0.456 *	0.475 *
March	**0.835** **	**0.818** ***	**1.339** ***	0.651 ***	0.672 ***	0.752 ***	0.661 ***	0.673 ***	0.738 ***
April	0.441	**0.537** ***	**0.664** *	0.547 ***	0.522 ***	0.516 ***	0.520 ***	0.503 ***	0.508 ***
May	**0.624** **	0.211	-0.082	0.475 ***	0.345 ***	0.284 ***	0.447 ***	0.317 ***	0.270 ***
June	**0.752** ***	**0.476** ***	**0.422** ***	0.516 ***	0.390 ***	0.344 ***	0.467 ***	0.348 ***	0.320 ***
July	0.227	0.331 ***	0.28	0.472 ***	0.411 ***	0.416 ***	0.402 ***	0.343 ***	0.359 ***
August	0.342	0.217 *	0.095	0.429 ***	0.363 ***	0.375 ***	0.343 ***	0.318 ***	0.363 ***
September	0.246	0.237	0.33	0.559 ***	0.486 ***	0.495 ***	0.517 ***	0.445 ***	0.456 ***
October	0.273	0.18	0.227	0.524 ***	0.434 ***	0.398 ***	0.496 ***	0.407 ***	0.372 **
November	0.386	0.183	0.252	0.569 ***	0.455 ***	0.368 **	0.503 ***	0.381 **	0.285
December	-0.137	-0.164	-0.025	0.394 ***	0.303 **	0.219	0.287 *	0.171	0.055

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level *p*<0.1, ** denotes the significance level *p*<0.05, and *** denotes the significance level *p*<0.01.

4. Line 128: How were 6-hourly data aggregated to the minimum and maximum temperature? Was any consideration given to the minimum/maximum temperature not occurring at 00, 6, 12, 18 UTC?

--Answer: Thanks a lot for pointing this out. The minimum and maximum temperatures are calculated from four temperature records. The observation standard of the China Meteorological Administration is also the instantaneous temperature four times a day, from 20 o'clock of previous day to 20 o'clock of current day at local time (UTC+8 Beijing time). The minimum/maximum temperature possible occurs at other time, rather than 00, 6, 12, 18 UTC. However, normally, the maximum temperature occurs around 14 o'clock (06:00 UTC). The minimum temperature occurs around 4 to 5 o'clock in the morning, which is close to 18 UTC (2 o'clock at Beijing time). Therefore, there is only limited effect for minimum and maximum temperature calculation from the 6-hourly data set.

5. Related to points 3 and 4: I'm surprised that in some cases, the warming increase in Tmin and Tmax are both greater than the warming increase in Tmean. This suggests some unusual shift in the shape of the diurnal cycle. Could the authors hypothesise as to why this might be?

--Answer: Thanks a lot for pointing this out. We checked the data carefully again. We found that the header of table does not correspond to the data. It means that the data is in the wrong column. We are very sorry for this kind of mistake that shouldn't be. We correct it in the revision.

Table 3. Annual and seasonal temperature trends (°C 10a^{-1}) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTM			WCC			LCC		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
Spring	0.633 ***	0.522 ***	0.640 ***	0.557 ***	0.513 ***	0.518 ***	0.543 ***	0.498 ***	0.505 ***
Summer	0.441 ***	0.342 ***	0.266 **	0.472 ***	0.388 ***	0.378 ***	0.404 ***	0.336 ***	0.348 ***
Autumn	0.302	0.200 *	0.270	0.551 ***	0.458 ***	0.420 ***	0.506 ***	0.411 ***	0.371 ***
Winter	0.014	-0.085	0.115	0.432 ***	0.361 ***	0.327 ***	0.333 **	0.257	0.211
Annual	0.347 ***	0.245 ***	0.323 ***	0.503 ***	0.430 ***	0.411 ***	0.446 ***	0.376 ***	0.359 ***

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

Table 4. Monthly temperature trends (°C 10a^{-1}) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTMD			**WCC**			**LCC**		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
January	-0.133	-0.269	-0.235	0.343 **	0.256	0.212	0.225	0.143	0.102
February	0.313	0.177	**0.605** **	0.558 ***	0.523 ***	0.549 **	0.486 **	0.456 *	0.475 *
March	**0.835** **	**0.818** ***	**1.339** ***	0.651 ***	0.672 ***	0.752 ***	0.661 ***	0.673 ***	0.738 ***
April	0.441	**0.537** ***	**0.664** *	0.547 ***	0.522 ***	0.516 ***	0.520 ***	0.503 ***	0.508 ***
May	**0.624** **	0.211	-0.082	0.475 ***	0.345 ***	0.284 ***	0.447 ***	0.317 ***	0.270 ***
June	**0.752** ***	**0.476** ***	**0.422** ***	0.516 ***	0.390 ***	0.344 ***	0.467 ***	0.348 ***	0.320 ***
July	0.227	0.331 ***	0.28	0.472 ***	0.411 ***	0.416 ***	0.402 ***	0.343 ***	0.359 ***
August	0.342	0.217 *	0.095	0.429 ***	0.363 ***	0.375 ***	0.343 ***	0.318 ***	0.363 ***
September	0.246	0.237	0.33	0.559 ***	0.486 ***	0.495 ***	0.517 ***	0.445 ***	0.456 ***
October	0.273	0.18	0.227	0.524 ***	0.434 ***	0.398 ***	0.496 ***	0.407 ***	0.372 **
November	0.386	0.183	0.252	0.569 ***	0.455 ***	0.368 **	0.503 ***	0.381 **	0.285

December	-0.137	-0.164	-0.025	0.394 ***	0.303 **	0.219	0.287 *	0.171	0.055

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level *p*<0.1, ** denotes the significance level *p*<0.05, and *** denotes the significance level *p*<0.01.

6. Section 3.3: This analysis of the spatial variations is interesting, and Figures 5-7 quite well represent the first requirement for EDW, that the warming in the region is greater than the surrounding area. However, it is difficult to see the altitude warming amplification from these plots unless you are well-acquainted with the topography of the region (e.g. from figure 5b it's only really possible to see a north-south gradient in area 1, it's not clear that that corresponds with high-low). Would it be possible to add (small) plots such as those in figures 2-4 to figures 5-7 for each region? If it's not possible to fit the graphs on, perhaps the trends and significance could be calculated, such as in figure 2-4? As in point 1, only those areas which fit both criteria should be described as EDW.

--Answer: Thanks a lot for the comment. The reviewer provided a very good suggestion to show the difference in spatial variations. The sub-plot is feasible. We select a certain direction in typical zone 2, and then establish a terrain profile with the corresponding temperature trend. Fox example:

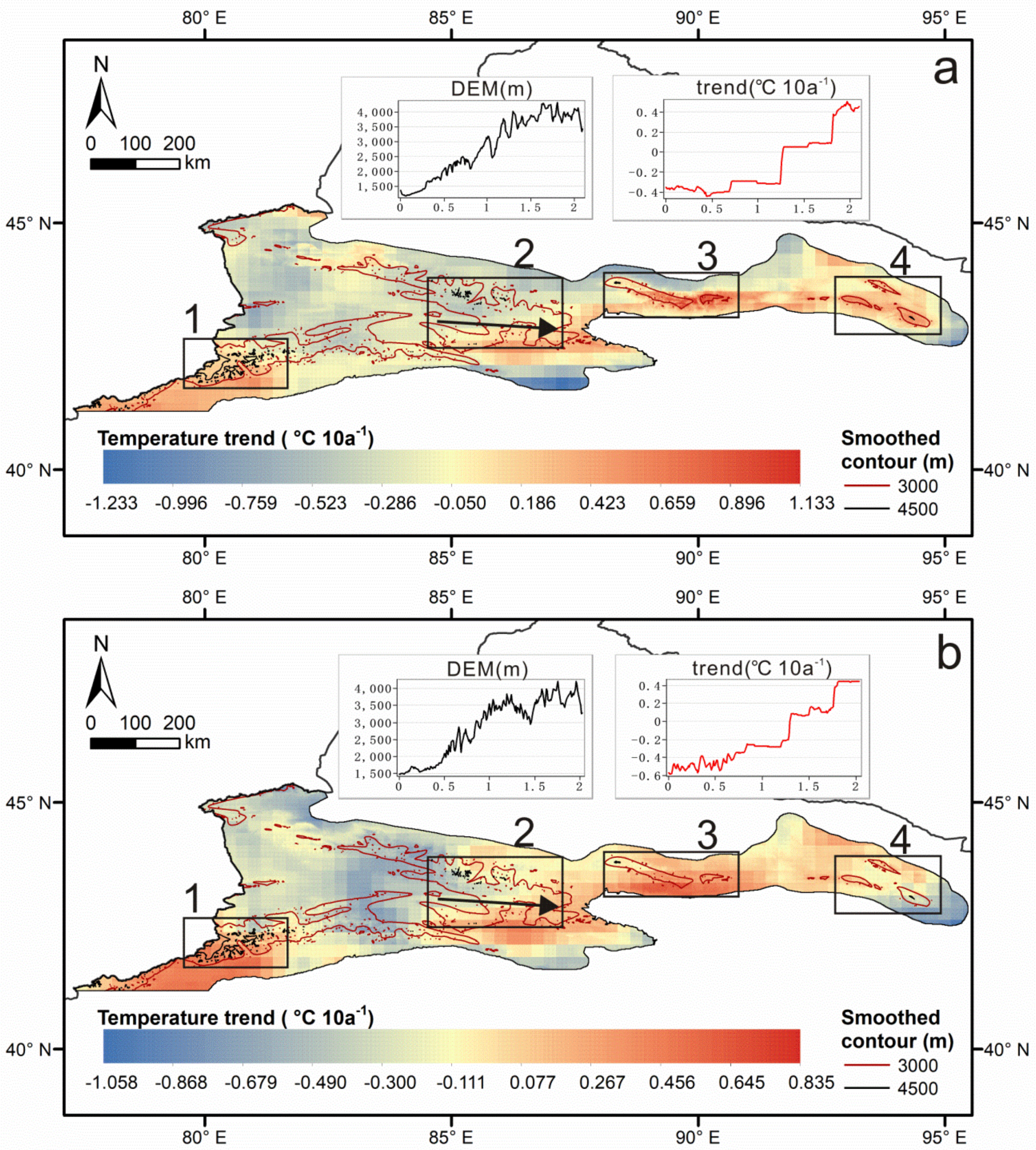

Figure 5: Monthly minimum temperature trends (a) January and (b) December for the entire CTM from 1979–2016. The ordinate of two sub-plots show the elevation trend and temperature trend along the terrain profile (black arrow indicates the direction) in Zone 2, respectively. The abscissa represents the distance in multiples of the scale.

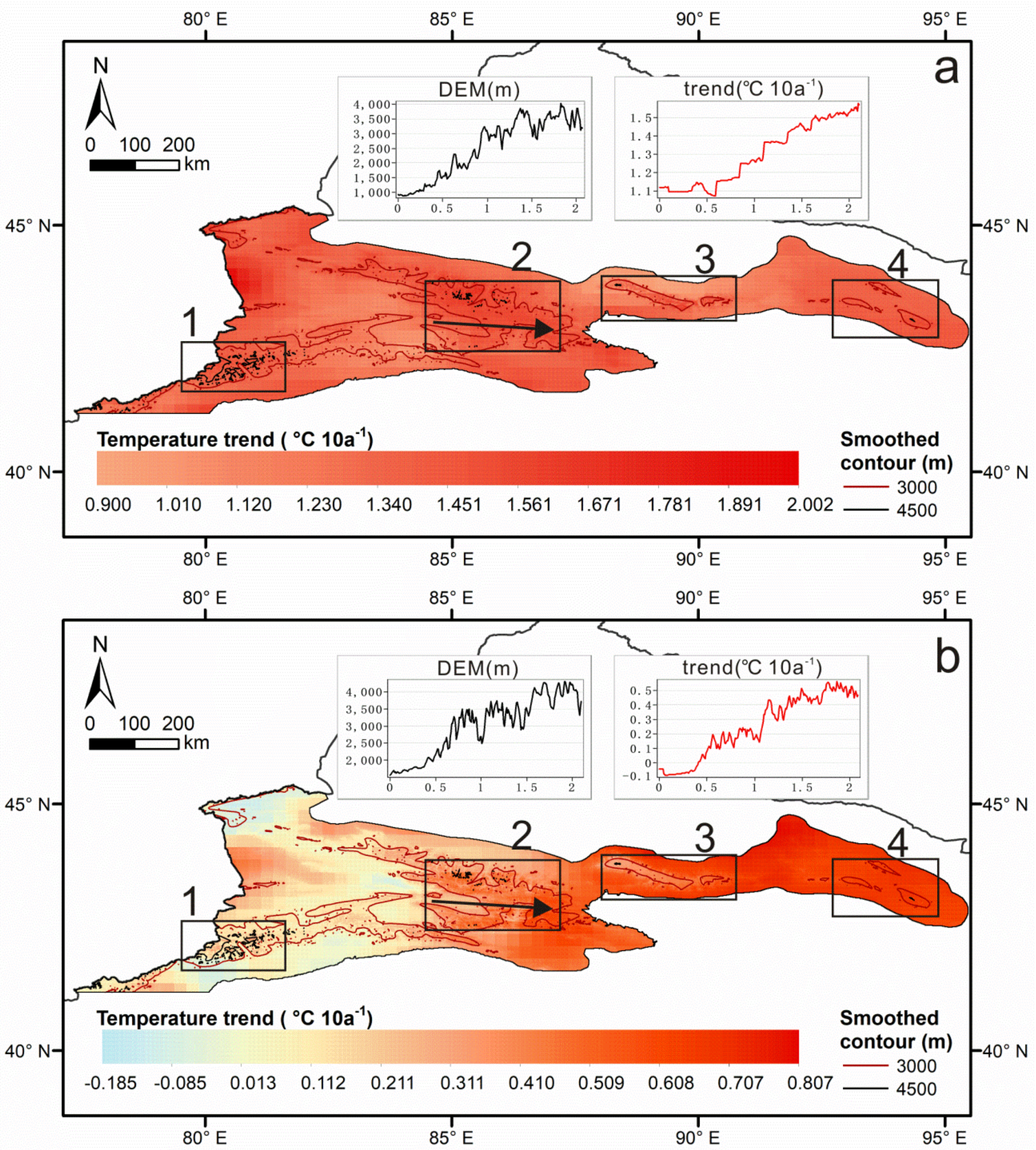

Figure 6: Monthly maximum temperature trends (a) March and (b) September for the entire CTM from 1979–2016. The ordinate of two sub-plots show the elevation trend and temperature trend along the terrain profile (black arrow indicates the direction) in Zone 2, respectively. The abscissa represents the distance in multiples of the scale.

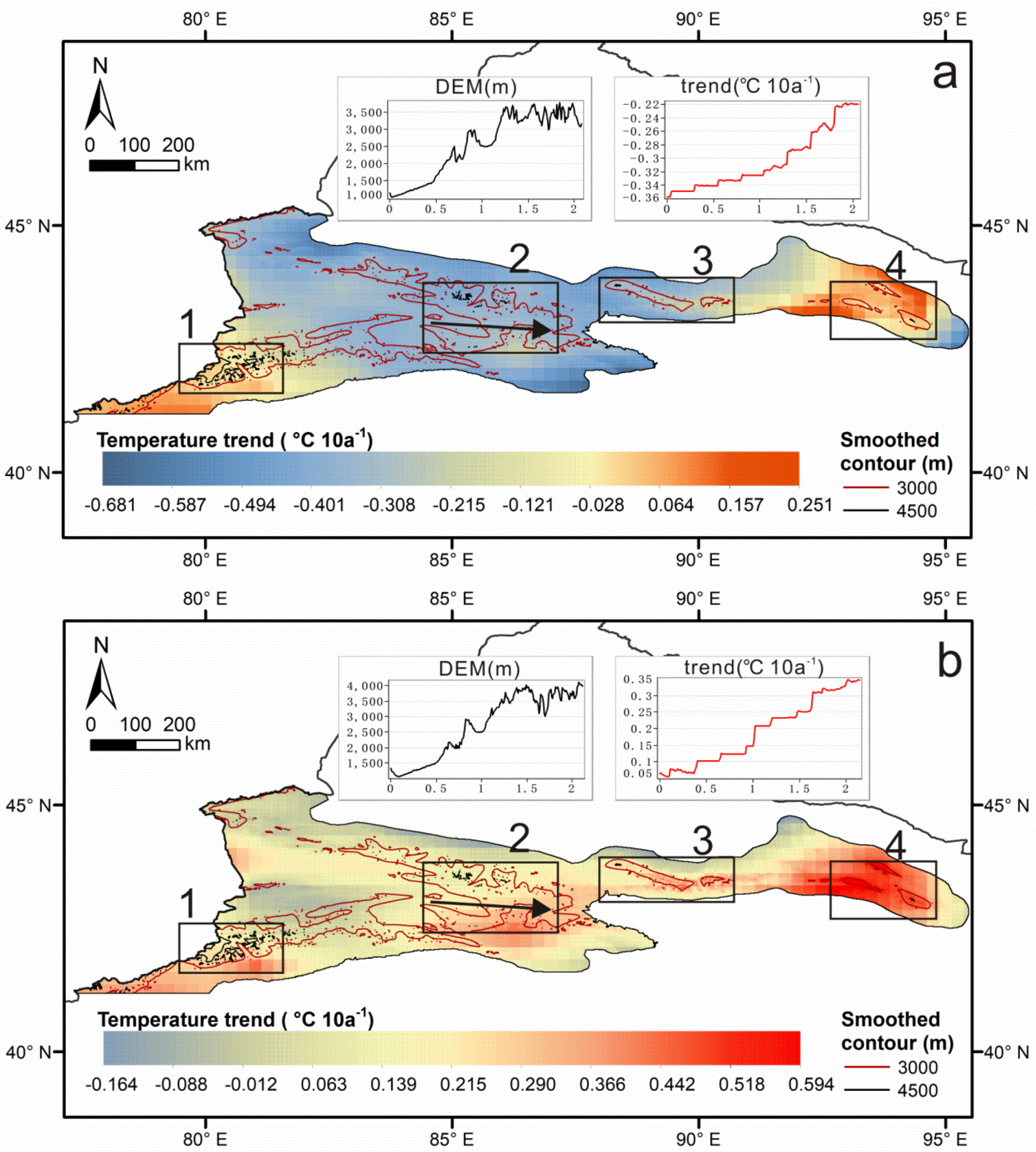

Figure 7: Monthly mean temperature trends (a) January and (b) February for the entire CTM from 1979–2016. The ordinate of two sub-plots show the elevation trend and temperature trend along the terrain profile (black arrow indicates the direction) in Zone 2, respectively. The abscissa represents the distance in multiples of the scale.

Smaller remarks, technical comments and suggestions:

7. Figure 1: Does the bottom right hand corner map show the extent of the CMA05 used in this analysis? If so, please add to the caption. If not, could this be altered to show the CMA05 extent?

--Answer: Thanks a lot for pointing this out. We will revise and add the grid points of CMA05 in the Figure 1.

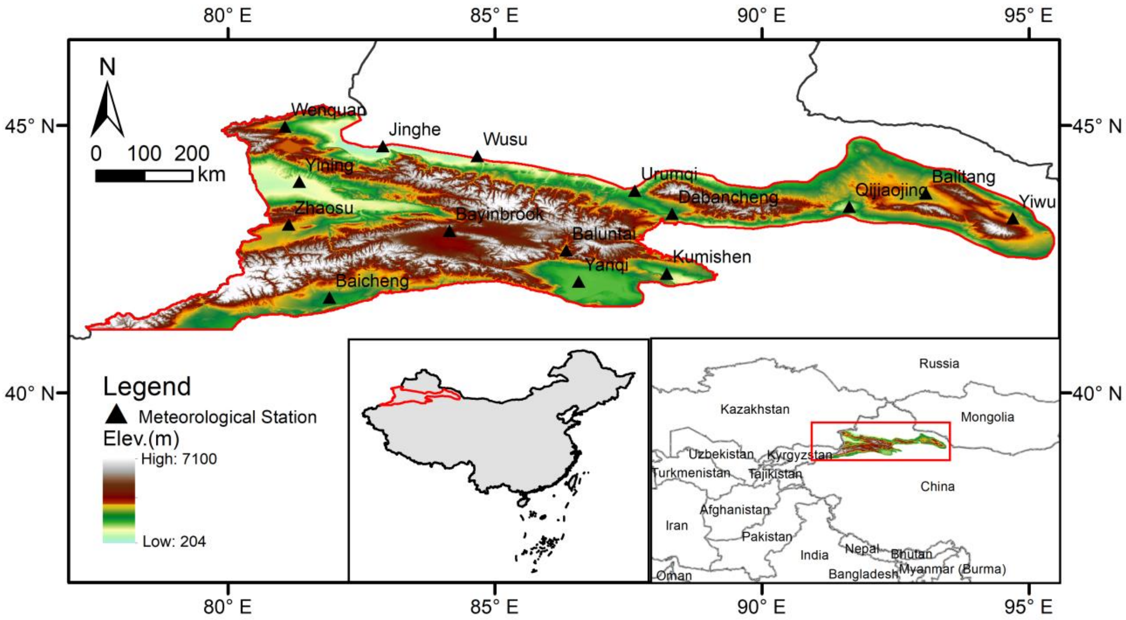

Figure1: Location of the Chinese Tianshan Mountains (CTM).The elevation ranges from 204 m to 7100 m a.s.l., with a DEM resolution of 1 km from SRTM. The grey sub-plot show the extent of the CMA05 at 0.5 °×0.5 °grid.

8. Introduction: It would be useful to make clear earlier on in the paper that EDW is referring to the rate of warming over a multi-annual scale (rather than, say, rate of warming during the day). This is made clear on line 58 with 'warming trend of annual mean temperature' but could be mentioned earlier.

--Answer: Thanks a lot for pointing this out. We modified the expression in the section 2.4 Analytical methods in the revision.

9. Around line 120 onwards-perhaps mention that the topography comes from SRTM.

--Answer: Thanks a lot for pointing this out. We clarify the source of DEM that comes from SRTM. It is also noted in the caption of Figure 1.

10. Line 136-137: it might be sensible to combine the highest two elevation bands, given that the highest only contains 4 points (which may not be representative in general).

--Answer: Thanks a lot for pointing this out. The referee is right that only four grids above than 7000m. However, we tend to keep these 4 grids because they represent the highest peaks in the entire CTM. Meanwhile, these four grids basically have the similar performance as that of 6500-7000m group.

11. Line 268-270: I think this sentence can be removed as you're only talking about surface albedo here.

--Answer: Thanks a lot for pointing this out. We removed it in the revision.

12. Line 113: remove 'because' (either 'because the system....,the bias could be' or 'The system bias of.... Thus, the bias...'

--Answer: Thanks a lot for pointing this out. We corrected it in the revision.

13. Please consider changing the colour bars in Figs. 5 to 7 so that they are all the same (and ideally centred around 0, so that red is positive, blue is negative and yellow around zero). At first glance it seems that the maximum temperature trends in March have both positive and negative values, which as you point out in the text is not the case. In addition, please flip the colour bars so that negative values are on the left and positive on the right.

--Answer: Thanks a lot for the comment. The suggestion is excellent for improving the readable of figures. We revised the color bar in the revision. For example:

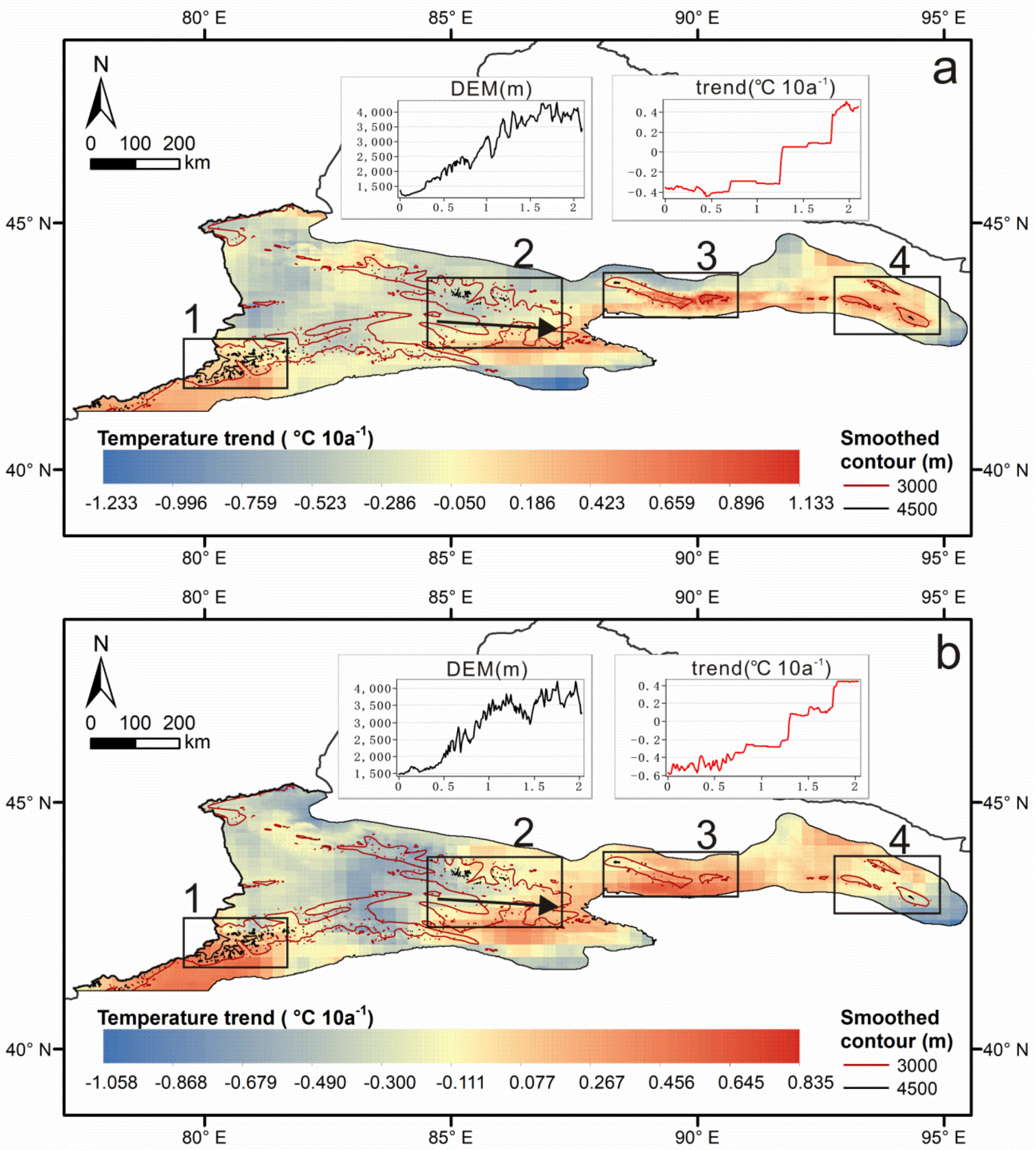

Figure 5: Monthly minimum temperature trends (a) January and (b) December for the entire CTM from 1979–2016. The ordinate of two sub-plots show the elevation trend and temperature trend along the terrain profile (black arrow indicates the direction) in Zone 2, respectively. The abscissa represents the distance in multiples of the scale.

14. Give the location of the Ili valley where it first appears on line 208, rather than 210. References Gao, L., Wei, J., Wang, L., Bernhardt, M., Schulz, K., and Chen, X.: A high-resolution air temperature data set for the Chinese TianShan in1979–2016, Earth System Science Data, 10, 2097-2114, 2018.

--Answer: Thanks a lot for pointing this out. We revised it in the revision.

Reference:

Deng, H., Chen, Y., and Li, Y.: Glacier and snow variations and their impacts on regional water resources in mountains, Journal of Geographical Sciences, 29(1): 84-100, 2019.

Gao, L., Bernhardt, M., and Schulz, L.: Elevation correction of ERA-interim temperature data in complex terrain, Hydrology and Earth System Sciences, 16(12): 4661-4673, 2012.

Simmons, A. J., Willett, K. M., Jones, P. D., Thorne, P. W., and Dee, D. P.: Low-frequency variations in surface atmospheric humidity, temperature, and precipitation: Inferences from reanalyses and monthly gridded observational data sets, J. Geophys. Res.-Atmos., 115, D01110, doi:10.1029/2009jd012442, 2010.

Response to Referee 3

We would like to thank anonymous Referee 3 for reviewing our manuscript. These constructive comments are very important for us to improve the present manuscript. In the following, we address all comments point-by-point according to referee's comments.

General comments:

Gao and co-authors present an analysis of decadal air temperature trends against elevation to explore the case for elevation dependent warming (EDW) in the Chinese Tianshan Mountains (CTM). The authors explore this across a large domain using a recent 1km resolution product derived based upon ERA-Interim reanalysis and station data up to 3000 m a.s.l. They find that for given months and sub-domains of the CTM, EDW is evident, though is complex and not consistent or clear for all domains or seasons. The manuscript is well written in parts and explores a very interesting and relevant topic within the cryosphere. While the work has particular value to be published in the journal, I believe much more needs to be done to explain the data sources and their limitations, to convince the reader of the validity of CTMD product and therefore the uncertainty and limitations of their results as well as providing more justification and better presentation of the key findings.

General Comments I think the manuscript has promise and could be substantially improved based upon some key things.

1) The authors give general reference to their ESSD paper for details about the CMTD product, but a much stronger section of the data and methods need to be presented for this manuscript in order to summarise the key details about how the CMTD was derived, for what time scale it is processed and what the major assumptions or limitations are that might affect the analysis of EDW. It's

apparent to me that the authors are already considering these limitations etc, based upon their responses to other reviewers on the open-discussions. To the reader of this manuscript, there is not enough information presented to judge the quality of the CTMD and assess the validity of the results that are based upon it.

-Answer: Thanks a lot for the comments. The reviewer raised a very important issue as the referee 2 has pointed out before. The data set CTMD is the most important basis for EDW analysis in this study. We know that the credibility of the data set determines the reliability of EDW detection. Indeed, we did not provide much information (such as data production process) on the data set while we focused more on EDW analysis. We agree with the referee that the limitations of the CTMD should be fully demonstrated in the manuscript for better understanding of readers especially who are the potential data users. We revised as follows:

Although, the CTMD was validated by 24 meteorological stations on a daily scale, indicating a high reliability for the climatology trend investigations, the limitations should be fully demonstrated. Whether the lapse rate can accurately reflect the temperature changes at altitudes is worth discussing. For example, the lapse rates of ERA-Interim are greater than observations from September to December, while lapse rate in the free atmosphere is steeper than that near ground because of the different radiation mechanism (Gao et al., 2018a). The lapse rate may be positive rather than negative since the “Cold Lake” effect in winter such as in the Turfan Basin, which may have a temperature inversion layer at night. Under this situation, the downscaling model may be disabled for winter. Therefore, an opposite trend for minimum temperature during winter is captured by the CTMD compared to the slight positive warming trend from 24 sites. Meanwhile, the trend of diurnal temperature range (DTR) is not captured very well by the CTMD in spring and autumn (Gao et al., 2018a). We want to emphasize that the CTMD is only validated by 24 sites, which are mainly in low terrains. The credibility of the CTMD in the high peaks is difficult to evaluate because of few observations exist. However, we believe that the CTMD is still creditable since it could capture the distribution characteristics of temperatures as well as the general warming trends.

2) I have the same issue as 1), but also for the CMA05 product. I am left questioning the comparability of the two for the tabular information presented (the first criterion of EDW that is the regionally amplified warming). For the CMA05, all pixels are averaged to produce a temperature/warming trend for all elevations across the entirety of China? Is this dataset also derived from ERA-I? Does it include the CTM as well, or all the rest of China except the study domain? If it is all of China, this then also includes other mountain regions of the country? In general, I like the succinct and to-the-point paper, but there are a lot of important pieces of information that are missing and without them, the reader cannot gain a good appreciation of the scientific rigour and value of the authors work. Being clearer about some of those elements will greatly aid the scientific conclusions.

-Answer: Thanks a lot for the comments. The referee is right that the information on the CMA05 is not enough for the readers. We will add more details on the processes of CMA05. In this study, the CMA05 which covers the whole continental China (including the CTM) was compared to CTMD. We think the referee provides a good idea that the CMA05 without the CTM can also be compared. Thus, we added the trend analysis using the CMA05 excluded the CTM as well as the CMA05 excluded the Tibetan Plateau (The TP is considered to be one of the most intense warming regions in China) in the revision.

Table 3. Annual and seasonal temperature trends (°C 10a^{-1}) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTM			WCC			LCC		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
Spring	0.633 ***	0.522 ***	0.640 ***	0.557 ***	0.513 ***	0.518 ***	0.543 ***	0.498 ***	0.505 ***
Summer	0.441 ***	0.342 ***	0.266 **	0.472 ***	0.388 ***	0.378 ***	0.404 ***	0.336 ***	0.348 ***
Autumn	0.302	0.200 *	0.270	0.551 ***	0.458 ***	0.420 ***	0.506 ***	0.411 ***	0.371 ***
Winter	0.014	-0.085	0.115	0.432 ***	0.361 ***	0.327 ***	0.333 **	0.257	0.211

Annual	0.347 ***	0.245 ***	0.323 ***	0.503 ***	0.430 ***	0.411 ***	0.446 ***	0.376 ***	0.359 ***

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

Table 4. Monthly temperature trends (°C $10a^{-1}$) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTMD			**WCC**			**LCC**		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
January	-0.133	-0.269	-0.235	0.343 **	0.256	0.212	0.225	0.143	0.102
February	0.313	0.177	**0.605** **	0.558 ***	0.523 ***	0.549 **	0.486 **	0.456 *	0.475 *
March	**0.835** **	**0.818** ***	**1.339** ***	0.651 ***	0.672 ***	0.752 ***	0.661 ***	0.673 ***	0.738 ***
April	0.441	**0.537** ***	**0.664** *	0.547 ***	0.522 ***	0.516 ***	0.520 ***	0.503 ***	0.508 ***
May	**0.624** **	0.211	-0.082	0.475 ***	0.345 ***	0.284 ***	0.447 ***	0.317 ***	0.270 ***
June	**0.752** ***	**0.476** ***	**0.422** ***	0.516 ***	0.390 ***	0.344 ***	0.467 ***	0.348 ***	0.320 ***
July	0.227	0.331 ***	0.28	0.472 ***	0.411 ***	0.416 ***	0.402 ***	0.343 ***	0.359 ***
August	0.342	0.217 *	0.095	0.429 ***	0.363 ***	0.375 ***	0.343 ***	0.318 ***	0.363 ***
September	0.246	0.237	0.33	0.559 ***	0.486 ***	0.495 ***	0.517 ***	0.445 ***	0.456 ***
October	0.273	0.18	0.227	0.524 ***	0.434 ***	0.398 ***	0.496 ***	0.407 ***	0.372 **
November	0.386	0.183	0.252	0.569 ***	0.455 ***	0.368 **	0.503 ***	0.381 **	0.285
December	-0.137	-0.164	-0.025	0.394 ***	0.303 **	0.219	0.287 *	0.171	0.055

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

3) In some places, a justification for showing some months and not others are needed. Figures for Tmin, Tmax and Tmean all show different months, for example. Is this purely just to show the months with the strongest trends? Some work needs to go into the figures as well. I see that that has begun already based upon comments fromreviewer#2. In each figure, the authors show different scales (y-axis limits are different in Figures 2-4 and colour scales are different in each subplot for Figures 5-7), and it becomes hard for the reader to easily compare and understand them, and take away the key message(s). See specific comments on the figures below.

-Answer: Thanks a lot for pointing this issue out. We must admit that the representative months we selected indeed have a significant warming trend. But it is not limited to these four months. We have shown the warming trend for all months in the Supplementary material. Here we want to clarify that we did not use a uniform scale (y-axis limits). We have tried. But the temperature increasing trend for some months at some elevation groups are negative. If a uniform scale used, the possible range could be -1.6 to 2 ˚C $10a^{-1}$. Thus, for some months, the box plot will appear very crowded and small, which is in a poor readable for the percentile ranges (25% to 75%). Thus, we keep the different y-axis ranges. However, the referee's comment is reasonable. We figure out a good way to show the trend comparison for all month is adding a table which including all slope and significance levels. The table is as following:

Table 5. Monthly temperature trends (°C $10a^{-1}$) over different elevations based on CTMD from 1979–2016.

	Tmin	Tmean	Tmax
January	0.039^{***}	0.036^{***}	0.037^{***}
February	0.033^{***}	0.012	0.008^{***}
March	0.023	0.009^{**}	0.017^{***}
April	0.021^{***}	-0.02^{***}	$\underline{\mathbf{0.069}}^{***}$
May	-0.056^{***}	-0.022^{***}	-0.045^{***}
June	-0.025^{***}	0.007	-0.046^{***}
July	0.0	-0.017^{**}	-0.019^{**}
August	-0.011	$\underline{\mathbf{0.037}}^{***}$	$\underline{\mathbf{0.023}}^{***}$
September	-0.006	$\underline{\mathbf{0.017}}^{**}$	$\underline{\mathbf{0.038}}^{***}$
October	-0.073^{***}	-0.018^{***}	$\underline{\mathbf{0.017}}^{**}$
November	-0.032^{***}	-0.031^{***}	-0.018^{***}
December	0.064^{***}	$\underline{\mathbf{0.006}}^{**}$	-0.018^{***}

Note: the bold and underlined value indicates a warming trend for higher elevations, not for the whole elevation range. More details could be found in Figure 2 to 4 and Figure S1 to S12. * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

4) The manuscript presents a rather general discussion with little further exploration of possible mechanisms. There is a repetition of general comments regarding, for example, the albedo's role on the surface energy balance, but this never links with why we may see EDW in certain months or why the strongest warming may occur only for Tmin in January/December and why Tmax trends or regional (east-west) temperature trends (e.g. Figure 5) might

occur. A reference of Deng et al. 2019 is given, for example, but it is not elaborated upon much. Can this or other datasets or analyses regarding snow cover/albedo from MODIS tell us more about why EDW might be occurring for certain seasons/mountains/zones? I don't suggest that the authors do a full analysis of snow cover, but some additional and more in-depth discussion points are definitely required.

-Answer: Thanks a lot for the comments. The reviewer pointed a very key issue. The physical mechanism of EDW is indeed a challenge issue. The current researches are more about the hypothetical mechanism, rather than quantitative physical mechanism investigation. The reviewer's comment is very constructive. We added the snow cover rate and snow depth data in the analysis, and the relationship between snow and temperature is discussed in the revision. For example:

Deng et al (2019) found that the snow cover rate in the CTM decreased from 2002-2013 at a rate of 0.44%. According to the snow cover rate data from Chen et al (2016) and Deng et al (2019), the maximum snow cover rate always occurred in January, while the minimum snow cover happened in July. We tested the relationship between monthly Tmin, Tmean and Tmax and maximum/minimum snow cover rate for each month in 2002-2013. Figure 8 shows the relationship of temperature and snow cover rate. Only February Tmin has a strong correlation ($R^2=0.302$, $p<0.1$) with the maximum snow cover rate (Fig. 8a). For minimum snow cover rate, Tmax in August has a significant correlation ($R^2=0.256$, $p<0.1$) with it (Fig. 8a). The correlation between temperatures in other months and snow cover rate is not significant.

Based on the snow depth data, the trend is calculated. The annual trend of snow depth over the CTM from 1979-2016 is -0.12 cm $10a^{-1}$, which means the snow is accelerated melting. Except January (0.16 cm $10a^{-1}$) and February (0.05 cm $10a^{-1}$), snow depth decreases in other months ranged from -0.01 to 0.58 cm $10a^{-1}$. The snow depth decreases the fastest in March with a rate of -0.58 cm $10a^{-1}$, followed by April with a rate of -0.45 cm $10a^{-1}$. Thus, spring has the highest decreasing trend of snow depth. However, the temperature trends are most significant in spring and March with respect to Tmin, Tmean and Tmax (Table 3 and 4). The relationship between snow depth and temperature is further investigated in the CTM from 1979-2016 (Table 6). A significant correlation ($p<0.01$) could be found between Tmin and snow depth in March and June. For the couple of Tmean and snow depth, the remarkable correlation ($p<0.01$) also could be found in March, June and August. The significant correlation ($p<0.01$) only could be found in December between Tmax and snow depth (Table 6). In some cold months, for example, November and January, a relative significant correlation ($p<0.05$) can be found between Tmean/Tmax and snow depth. Figure 9 shows the scatter plots of comparison of Tmin and Tmean in March with snow depth. The negative correlation is perspicuous and visible. In general, there is a negative correlation between temperature and snow cover/snow depth (Figs. 8 and 9), which implies that the temperature warming has an effect on the accelerated melting of snow, or the melting of snow affect the temperature warming. The detailed feedback mechanism between snow and temperature needs to be further verified and explored by using more advanced technology and models. In summary, although many hypothetical mechanisms of EDW have received widespread attention, most of them are limited to phenomenon description and qualitative analysis. However, the present study tried to do some preliminary explorations on the mechanism based on limited snow cover and snow depth data.

Table 6. Relationship (R^2) of snow depth (cm) and monthly Tmin, Tmean and Tmax from 1979-2016.

	Tmin	Tmean	Tmax
January	0.021	0.098 *	0.109 **
February	0.031	0.050	0.103 *
March	0.399 ***	0.400 ***	0.033
April	0.003	0.076	0.008
May	0.086 *	0.104 *	0.012
June	0.194 ***	0.230 ***	0.095 *
July	0.081 *	0.108 *	0.016
August	0.047	0.242 ***	0.083 *
September	0.001	0.072	0.150 **
October	0.010	0.020	0.103 *
November	0.051	0.125 **	0.151 **
December	0.014	0.159 **	0.200 ***

Note: * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

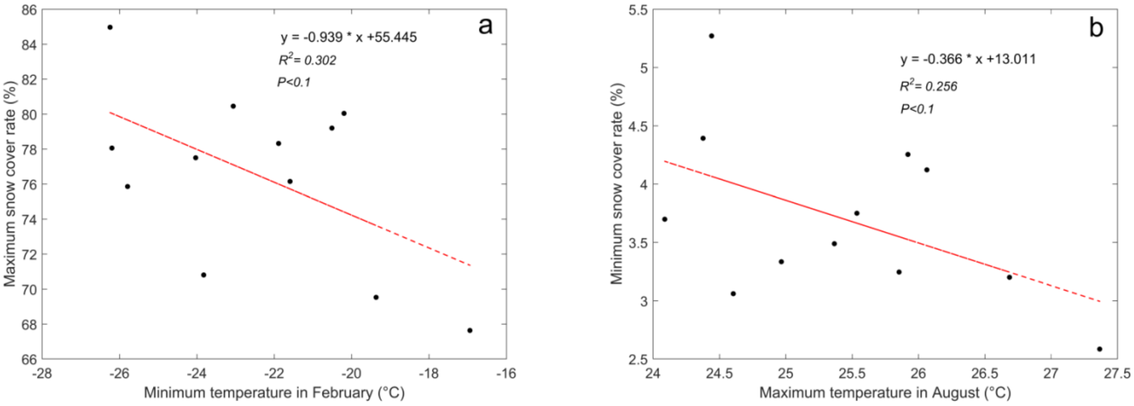

Figure 8: Relationship of temperature and snow cover rate (a) minimum temperature in February vs. maximum snow cover rate and (b) maximum temperature in August vs. minimum snow cover rate from 2002-2013.

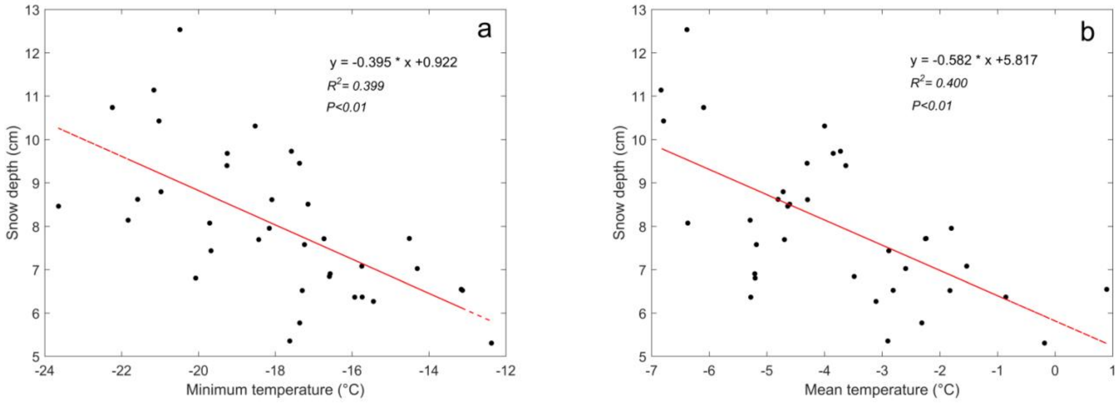

Figure 9: Relationship of snow depth and (a) Tmin in March and (b) Tmean in March from 1979-2016.

5) Finally, throughout the manuscript, the terminology of EDW and trends/gradients shifts somewhat and consistency is required throughout (following a clear initial definition). Moreover, the use of the word 'significantly' comes up a lot to refer to differences in trends across space (for the maps) and time (for seasons/months). Unless these differences are tested for significance and values reported, care should be taken for the wording and adjusted appropriately.

-Answer: Thanks a lot for the comments. The referee 2 also pointed out the terminology problem. We admit that we did not give a very clear definition on

EDW, even some misunderstanding. In the revision, we clarified the EDW definition as well as its features. The trends indeed represent different means respect to space and temporal scale.

Specific comments:

6) Abstract L26 -What are EDW 'Features'? I would consider rewording this.

-Answer: Thanks a lot for the comments. To be precise, regional warming amplification and altitude warming amplification are the two basic EDW characteristics. We reword this part in the revision.

7) L26-27 – Please add here the time period over which CMTD was derived and analysed (1979- 2016?)

-Answer: Thanks a lot for the comments. We added the time series 1979-2016 in the revision.

8) L28 – Statistically significant elevation dependence? Add that if so.

-Answer: Thanks a lot for the comments. We added the statistical significances in the revision.

9) L34 – While I do not disagree that this is a likely contributor to glacier melt in the CTM, the authors do not explicitly 'explain' this link, especially as the EDW trends are not so clear for all summer months. It's possible that stronger trends in warming at high elevations in April could have a key influence on some more precipitation falling as rain, but again, the authors cannot (based upon the presented work) state this. I would rephrase this to something like "This new evidence could partly explain the accelerated melting of glaciers in the CTM, though the mechanisms remain to be explored" or similar.

-Answer: Thanks a lot for the comments. Our conclusion may be a little bit arbitrary. We revised this part in the revision.

Introduction

10) L36 – two ‘criteria

-Answer: Thanks for pointing this out. We revised it in the revision.

11) L50 – Current ‘evidence’

-Answer: Thanks for pointing this out. We revised it in the revision.

12) L54 – Please elaborate here and add some reasoning of seasonal significance from those studies.

-Answer: Thanks for pointing this out. We added specific information on it in the revision.

13) L58 – What is global mountain detection? Do the authors refer to detection of trends or ‘observations’ in general for mountain regions? Please clarify and reword.

-Answer: Thanks for pointing this out. “Global mountain detection” means the researcher investigated the temperature trends for most of large mountains over the world. We revised this literature.

14) L58-74 This paragraph reads rather disjointed without a clear flow or argument. Because it recounts several other instances of studies exploring EDW, the overview might be more valuable to the reader in a tabular format? I would suggest to restructure this paragraph and improve the flow of the writing.

-Answer: Thanks for pointing this out. We restructured this paragraph and improve the flow of the writing in the revision.

15) L72-73 – Please clarify what satellite data the authors refer to and how that shows EDW/climate warming at specified elevations. How does this point fit

into the context of the manuscript discussion and/or the strengths/limitations of the presented dataset?

-Answer: Thanks for pointing this out. We revised the literatures in the revision.

16) L81 – Do the authors refer to 56 gridded points of a given product presented by You et al.? Please clarify and rewrite.

-Answer: Thanks for pointing this out. We clarified this literature in the revision.

17) L87 – To me the "largest independent latitudinal mountain system" is not clear. Can the authors clarify its meaning or remove it?

-Answer: Thanks for pointing this out. We removed it in the revision.

Data and Methods

18) L109 – CTMD is briefly defined at the end of the introduction, but should be described insufficient detailed before introducing other datasets to compare to it. See my general comment about elaborating on the CTMD product, especially on its derivation and potential limitations for exploring EDW in this manuscript.

-Answer: Thanks a lot for the comments. We added more information in the revision.

Although, the CTMD was validated by 24 meteorological stations on a daily scale, indicating a high reliability for the climatology trend investigations, the limitations should be fully demonstrated. Whether the lapse rate can accurately reflect the temperature changes at altitudes is worth discussing. For example, the lapse rates of ERA-Interim are greater than observations from September to December, while lapse rate in the free atmosphere is steeper than that near ground because of the different radiation mechanism (Gao et al., 2018a). The lapse rate may be positive rather than negative since the "Cold Lake" effect in winter such as in the Turfan Basin, which may have a temperature inversion layer at night. Under this situation, the downscaling model may be disabled for winter. Therefore, an opposite trend for minimum temperature during winter is captured by the CTMD compared to the slight positive warming trend from 24 sites. Meanwhile, the trend of diurnal temperature range (DTR) is not captured very well by the CTMD in spring and autumn (Gao et al., 2018a). We want to emphasize that the CTMD is only validated by 24 sites, which are mainly in low terrains. The credibility of the CTMD in the high peaks is difficult to evaluate because of few observations exist. However, we believe that the CTMD is still creditable since it could capture the distribution characteristics of temperatures as well as the general warming trends.

19) L111-Taking all elevations of CMA05? It is not clear how comparable these products are (see general comment). For the CTMD product, the definition of mountain domain is all of the CTMD pixels (including low elevations)? I am left questioning whether the comparison of the CTMD and CMA05 trends are valid and how the values for Table 1 were derived for each of them. More information is required here.

-Answer: Thanks a lot for the comments. We clarified this part and add more analysis in the revision.

Table 3. Annual and seasonal temperature trends (°C $10a^{-1}$) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTM			WCC			LCC		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
Spring	0.633 ***	0.522 ***	0.640 ***	0.557 ***	0.513 ***	0.518 ***	0.543 ***	0.498 ***	0.505 ***
Summer	0.441 ***	0.342 ***	0.266 **	0.472 ***	0.388 ***	0.378 ***	0.404 ***	0.336 ***	0.348 ***
Autumn	0.302	0.200 *	0.270	0.551 ***	0.458 ***	0.420 ***	0.506 ***	0.411 ***	0.371 ***
Winter	0.014	-0.085	0.115	0.432 ***	0.361 ***	0.327 ***	0.333 **	0.257	0.211
Annual	0.347 ***	0.245 ***	0.323 ***	0.503 ***	0.430 ***	0.411 ***	0.446 ***	0.376 ***	0.359 ***

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

Table 4. Monthly temperature trends (°C $10a^{-1}$) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

CTMD	WCC	LCC

	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
January	-0.133	-0.269	-0.235	0.343 **	0.256	0.212	0.225	0.143	0.102
February	0.313	0.177	**<u>0.605</u>** **	0.558 ***	0.523 ***	0.549 **	0.486 **	0.456 *	0.475 *
March	**<u>0.835</u>** **	**<u>0.818</u>** ***	**<u>1.339</u>** ***	0.651 ***	0.672 ***	0.752 ***	0.661 ***	0.673 ***	0.738 ***
April	0.441	**<u>0.537</u>** ***	**<u>0.664</u>** *	0.547 ***	0.522 ***	0.516 ***	0.520 ***	0.503 ***	0.508 ***
May	**<u>0.624</u>** **	0.211	-0.082	0.475 ***	0.345 ***	0.284 ***	0.447 ***	0.317 ***	0.270 ***
June	**<u>0.752</u>** ***	**<u>0.476</u>** ***	**<u>0.422</u>** ***	0.516 ***	0.390 ***	0.344 ***	0.467 ***	0.348 ***	0.320 ***
July	0.227	0.331 ***	0.28	0.472 ***	0.411 ***	0.416 ***	0.402 ***	0.343 ***	0.359 ***
August	0.342	0.217 *	0.095	0.429 ***	0.363 ***	0.375 ***	0.343 ***	0.318 ***	0.363 ***
September	0.246	0.237	0.33	0.559 ***	0.486 ***	0.495 ***	0.517 ***	0.445 ***	0.456 ***
October	0.273	0.18	0.227	0.524 ***	0.434 ***	0.398 ***	0.496 ***	0.407 ***	0.372 **
November	0.386	0.183	0.252	0.569 ***	0.455 ***	0.368 **	0.503 ***	0.381 **	0.285
December	-0.137	-0.164	-0.025	0.394 ***	0.303 **	0.219	0.287 *	0.171	0.055

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

<u>20) L112 – Can the authors define what is a small large scale error? Small biases over large domains?</u>

-Answer: Thanks for pointing this out. We clarified the bias is ±2.5 K and cited the reference in the revision.

<u>21) L113 – systematic?</u>

-Answer: Thanks for pointing this out. We corrected it in the revision.

<u>22) L116-118 – It would be valuable to recount that winter lapse rates were not well estimated by CTMD compared to the station data as shown by Fig. 4 of Gao et al., 2018. Some mention here (or in the discussion) needs to explore the potential impact that this might have on your results. If, for example, your temperatures at the highest elevations were estimated by the station lapse rates, would they be largely different from what the CTMD gives you? Could this strongly affect the EDW trends for the highest elevations in January/December? I don't expect that the authors should use the low-elevation stations to derive the high elevation temperatures for their analyses, but some discussion on the limitations of CTMD for the current</u>

analyses are required somewhere in the manuscript.

-Answer: Thanks a lot for the comments. The reviewer is right that the limitation of CTMD should be fully demonstrated in the discussion, especially the poor simulation of lapse rate by CTMD in winter.

Although, the CTMD was validated by 24 meteorological stations on a daily scale, indicating a high reliability for the climatology trend investigations, the limitations should be fully demonstrated. Whether the lapse rate can accurately reflect the temperature changes at altitudes is worth discussing. For example, the lapse rates of ERA-Interim are greater than observations from September to December, while lapse rate in the free atmosphere is steeper than that near ground because of the different radiation mechanism (Gao et al., 2018a). The lapse rate may be positive rather than negative since the "Cold Lake" effect in winter such as in the Turfan Basin, which may have a temperature inversion layer at night. Under this situation, the downscaling model may be disabled for winter. Therefore, an opposite trend for minimum temperature during winter is captured by the CTMD compared to the slight positive warming trend from 24 sites. Meanwhile, the trend of diurnal temperature range (DTR) is not captured very well by the CTMD in spring and autumn (Gao et al., 2018a). We want to emphasize that the CTMD is only validated by 24 sites, which are mainly in low terrains. The credibility of the CTMD in the high peaks is difficult to evaluate because of few observations exist. However, we believe that the CTMD is still creditable since it could capture the distribution characteristics of temperatures as well as the general warming trends.

23) L126 – reword to 'six-hourly timestep'

-Answer: Thanks for pointing this out. We corrected it in the revision.

24) L136-138 – fine, but maybe neaten, use of table?

-Answer: Thanks for pointing this out. We used a table here in the revision.

Table 1. Altitude groups in the CTMD.

	Altitude range (m)	Grid number
1	<500	3139

2	500–1000	30810
3	1000-1500	83018
4	1500-2000	70229
5	2000-2500	46545
6	2500-3000	43400
7	3000-3500	39579
8	3500-4000	28256
9	4000-4500	8789
10	4500-5000	1666
11	5000-5500	496
12	5500-6000	150
13	6000-6500	54
14	>6500	4

25) L139 – statistical significance of the linear regression? What p-value defines your statistical significance when you use the term significant in the abstract?

-Answer: Thanks a lot for the comments. We used 0.1, 0.05, and 0.01 for p-value to define statistical significance. We add this information for Table 3 and Table 4, as well as the abstract in the revision.

26) L141- averaged is mean or median? (cf boxplots with median red line plotted)

-Answer: Thanks a lot for the comments. Yes, the boxplots show the median value. We used the mean value for consistent trend calculation.

Results

27) L150 – This needs clarification. Do the authors refer to the elevation gradient of decadal temperature trends or the gradient (slope) of the regression line that quantifies the trend in each elevation band? If referring to the latter, please use the word trend (or similar) instead to not confuse with temperature gradient/lapse rate.

-Answer: Thanks for pointing this out. We clarified and used the term “trend ” in the revision.

28) L174 – Why those months only? How are they ‘representative’? Representative of what? I don’t see a clear segregation of season, January and December both have negative trends for the whole domain (converse to the CMA05), April is not as large an increase as March: : : More justification is needed. Are the authors simply showing all of the results which have more warming somewhere?

-Answer: Thanks a lot for the comments. The representative months we selected indeed have a significant warming trend. But it is not limited to these four months. We have shown the warming trend for all months in the Supplementary material. We will add more information on this part. We also add a table for Figure 2-4.

Table 5. Monthly temperature trends (℃ 10a^{-1}) over different elevations based on CTMD from 1979–2016.

	Tmin	Tmean	Tmax
January	0.039***	0.036***	0.037***
February	0.033***	0.012	0.008***
March	0.023	0.009**	0.017***
April	0.021***	-0.02***	**0.069*****
May	-0.056***	-0.022***	-0.045***
June	-0.025***	0.007	-0.046***
July	0.0	-0.017**	-0.019**
August	-0.011	**0.037*****	**0.023*****
September	-0.006	**0.017****	**0.038*****
October	-0.073***	-0.018***	**0.017****
November	-0.032***	-0.031***	-0.018***
December	0.064***	**0.006****	-0.018***

Note: the bold and underlined value indicates a warming trend for higher elevations, not for the whole elevation range. More details could be found in Figure 2 to 4 and Figure S1 to S12. * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

29) L176 – Is your average a Mean? Median? Note that median is displayed for boxplots.

-Answer: Thanks a lot for the comments. Because we calculated the monthly and seasonal temperature trends for each grid based on averaged 6-hourly data. Thus, we want to keep the consistent trend calculation for all parts. The boxplot shows the 25% to 75% range with the median value. The regression based on mean value reflects extra information for the whole figure.

30) L185 - Figure 3 now investigates March, April, August and September. Why are the same months not compared and what is the justification this time?

-Answer: Thanks for pointing this out. It illustrates the complexity and variability of EDW. Because the performance of different temperature type (Tmin, Tmean and Tmax) is diverse for different months. We try to select the months with the most significant temperature warming trend.

31) L193 – Months of interest for Tmean are again different.

-Answer: Thanks for pointing this out. Yes, the months of interest are different because the diverse performances for different months. We believe it is better to let the readers know which month has the intense warming trend.

32) L203 – Statistically significantly different? If so, by what test and what significance? Same comment throughout the paragraph, please clarify the significance or reword it.

-Answer: Thanks for pointing this out. We provided the p-value in the revision.

33) L207 – are warmer on average, the figure rather shows a higher rate of warming. Check sentence.

-Answer: Thanks for pointing this out. We reword this sentence in the revision.

Possible hypotheses and mechanisms

34) I feel that this section should be under the general header of 'discussion'. Please see general comments on this section. I believe that much more is

needed for this section. It is very general and I don’t go away feeling that I learned anything new.

-Answer: Thanks a lot for the comments. We changed this section to discussion and added the snow cover rate and snow depth data in the analysis. The relationship between snow and temperature is discussed in the revision. For example:

Deng et al (2019) found that the snow cover rate in the CTM decreased from 2002-2013 at a rate of 0.44%. According to the snow cover rate data from Chen et al (2016) and Deng et al (2019), the maximum snow cover rate always occurred in January, while the minimum snow cover happened in July. We tested the relationship between monthly Tmin, Tmean and Tmax and maximum/minimum snow cover rate for each month in 2002-2013. Figure 8 shows the relationship of temperature and snow cover rate. Only February Tmin has a strong correlation (R^2=0.302, p<0.1) with the maximum snow cover rate (Fig. 8a). For minimum snow cover rate, Tmax in August has a significant correlation (R^2=0.256, p<0.1) with it (Fig. 8a). The correlation between temperatures in other months and snow cover rate is not significant.

Based on the snow depth data, the trend is calculated. The annual trend of snow depth over the CTM from 1979-2016 is -0.12 cm $10a^{-1}$, which means the snow is accelerated melting. Except January (0.16 cm $10a^{-1}$) and February (0.05 cm $10a^{-1}$), snow depth decreases in other months ranged from -0.01 to 0.58 cm $10a^{-1}$. The snow depth decreases the fastest in March with a rate of -0.58 cm $10a^{-1}$, followed by April with a rate of -0.45 cm $10a^{-1}$. Thus, spring has the highest decreasing trend of snow depth. However, the temperature trends are most significant in spring and March with respect to Tmin, Tmean and Tmax (Table 3 and 4). The relationship between snow depth and temperature is further investigated in the CTM from 1979-2016 (Table 6). A significant correlation (p<0.01) could be found between Tmin and snow depth in March and June. For the couple of Tmean and snow depth, the remarkable correlation (p<0.01) also could be found in March, June and August. The significant correlation (p<0.01) only could be found in December between Tmax and snow depth (Table 6). In some cold months, for example, November and January, a relative significant correlation (p<0.05) can be found between Tmean/Tmax and snow depth. Figure 9 shows the scatter plots of comparison of Tmin and Tmean in March with snow depth. The negative correlation is perspicuous and visible. In general, there is a negative correlation between temperature and snow cover/snow depth (Figs. 8 and 9), which implies that the temperature warming has an effect on the accelerated melting of snow, or the melting of snow affect the temperature warming. The detailed feedback mechanism between snow and temperature needs to be further verified and explored by using more advanced technology and models. In summary, although many hypothetical mechanisms of EDW have received widespread attention, most of them are limited to phenomenon description and qualitative analysis. However, the present study tried to do some preliminary explorations on the mechanism based on limited snow cover and snow depth data.

Table 6. Relationship (R^2) of snow depth (cm) and monthly Tmin, Tmean and Tmax from 1979-2016.

	Tmin	Tmean	Tmax
January	0.021	0.098 *	0.109 **
February	0.031	0.050	0.103 *
March	0.399 ***	0.400 ***	0.033
April	0.003	0.076	0.008
May	0.086 *	0.104 *	0.012
June	0.194 ***	0.230 ***	0.095 *
July	0.081 *	0.108 *	0.016
August	0.047	0.242 ***	0.083 *
September	0.001	0.072	0.150 **
October	0.010	0.020	0.103 *
November	0.051	0.125 **	0.151 **
December	0.014	0.159 **	0.200 ***

Note: * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.

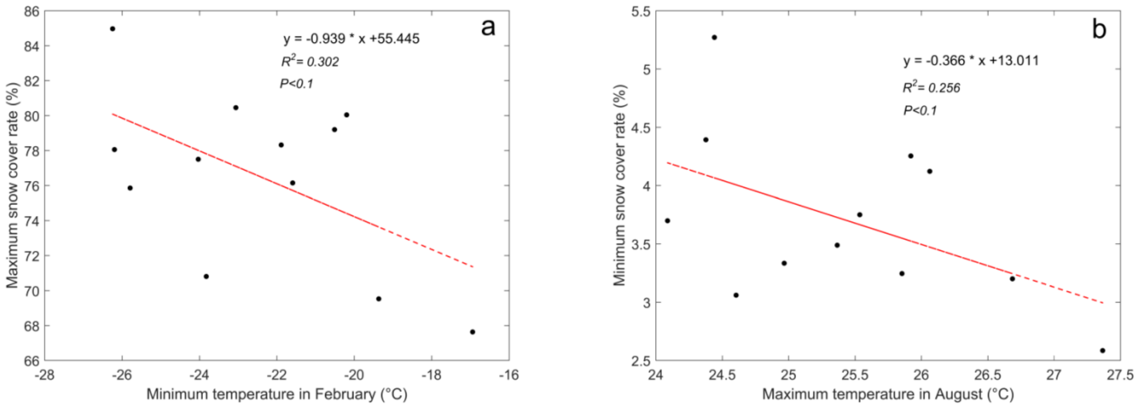

Figure 8: Relationship of temperature and snow cover rate (a) minimum temperature in February vs. maximum snow cover rate and (b) maximum temperature in August vs. minimum snow cover rate from 2002-2013.

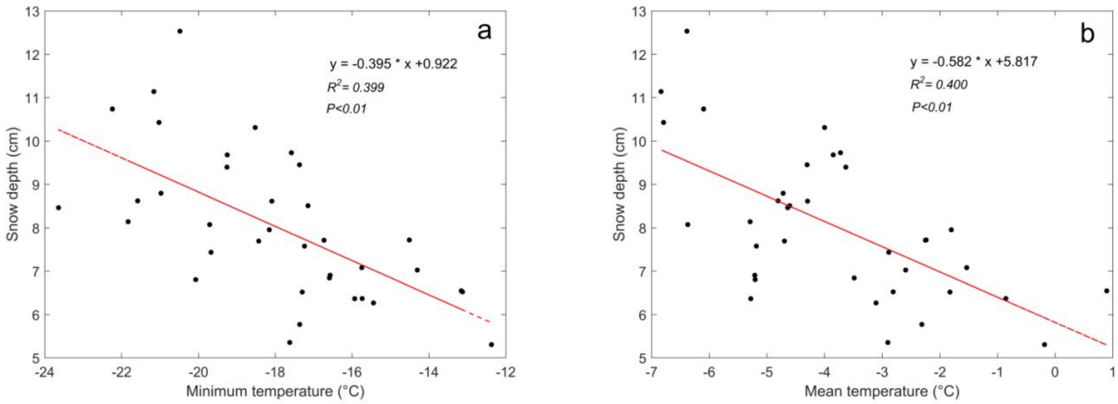

Figure 9: Relationship of snow depth and (a) Tmin in March and (b) Tmean in March from 1979-2016.

35) L255 – Also the snow cover and snow albedo here affect this: : : This is mentioned in the next paragraph and the information is essentially repeated with no additional information gain.

-Answer: Thanks for pointing this out. We reworded this paragraph in the revision.

36) L264-265 – Sure, this could be a mechanism, but has there been any other studies demonstrating snow cover changes and albedo changes in the CTM? I note that the Deng paper is cited but not investigated further. Because the CTMD product is generated through station observations at lower elevations, would this not bias representation of high elevation changes? Of course, I appreciate that there are no available data at those higher elevations, but this needs to be mentioned and limitations of the dataset/study need to be linked with a more in depth interpretation of the most noteworthy results.

-Answer: Thanks a lot for the comments. We will add more discussion about the impacts of snow/ice cover on the temperature changes in the revision. It is true that there are quite few observations at higher elevation to validate the

CTMD. The limitation of the CTMD is fully demonstrated in the revision. Please see the answers for Q34 and Q22.

37) L273 – Could be? Are these model simulations of idealised conditions or did authors find this specifically for that zone? Reword to 'estimated glacier mass loss: : :'

-Answer: Thanks for pointing this out. We corrected it.

38) L275 – 'In summary'

-Answer: Thanks for pointing this out. We corrected it in the revision.

Discussion and Conclusions

39) In my opinion, this section needs splitting into; 1) a greater discussion with section 4 (see general comment and above) and, 2) a clear and concise, separate conclusions section.

-Answer: Thanks for pointing this out. We rewrite and add more information in Section 4 in the revision.

40) L284 – 'DO' not (in the case of CTM) clearly reflect EDW. Not cannot.

-Answer: Thanks for pointing this out. We corrected it in the revision.

41) L285-286 – This belongs to the previous section. The authors should elaborate whether earlier spring snow melt is significant (and quantify significance) or at least demonstrate if past work suggests that warming at those higher elevations is more likely. Comparing some general estimates of snow line elevation or from previous findings to those same elevation bands would be of value, though I'm sceptical if the CTMD product will reflect that change.

-Answer: Thanks a lot for the comments. We added more analysis on the relationship between snow and temperature. Please check the Q34.

42) L288 – Replace gradients with trends unless referring specifically to the difference across the elevation bands (Figures 2-4). In general, the terminology needs clarification.

-Answer: Thanks for pointing this out. We corrected it in the revision.

43) L297 – I think that this is a crucial point. Above 5000 m, there are always positive trends for minimum and some mean temperatures (Figures 2 and 4). I would like to see more discussion as to why we might expect to have a general cooling (negative) trend for the winter minimum below 3000 m. The lack of discussion regarding the mechanisms is a major drawback to the current manuscript version.

-Answer: Thanks a lot for the comments. The reviewer pointed a very important issue. It is true that the discussion on the mechanism is not enough. The land surface process plays a key role regarding the mechanism. The air at high altitudes is similar to the free atmosphere and the dry adiabatic process is dominant. In low-altitude areas, the impact of underlying surface characteristics (e.g. terrain and land cover) is more significant. We added more in section 4 in the revision.

It is worth noting that the temperature trend is always positive at an altitude of 4500 m or higher. However, the temperature has a cooling trend in winter below 3000 m, especially Tmin (Fig. 2). The significant altitude warming amplification phenomenon only could be found above 4500 m for August Tmean (Fig. 3 and Table 5). The air at high altitudes is similar to the free atmosphere and the dry adiabatic process is dominant. The absorption and reflection of solar radiation by the surface mainly determine the temperature change. In low-altitude areas, the impact of underlying surface characteristics (e.g. terrain and land cover) is more significant. The CTM has a complex terrain with many mountain basins and canyons. Since the “Cold Lake” effect in winter, the lapse rate even is positive. A temperature inversion layer often happens in deep canyons at night. In low-altitude areas, the more surface soil moisture results in latent heat fluxes increasing, which further causes more absorbed solar radiation and then temperature warming in winter (Rangwala et al., 2012). This mechanism is closely related to snowlines and treelines because the migration of snowline and treeline changes the surface albedo (Mountain Research Initiative EDW Working Group, 2015).

44) L297-298 – Or could be warming as a result of snow cover depletion (feedback)?

-Answer: Thanks a lot for the comments. The melting and retreat of the snow cover will affect the surface albedo, which changes the surface energy balance. We discussed more in the section 4 in the revision.

45) L297-302 – This reads like a results section again.

-Answer: Thanks for pointing this out. We reworded it in the revision.

Figures

46) -My general issue with the figures is the lack of standardisation (i.e. different colour and y-axis scales) and the ever changing months presented. It leaves the reader with no strong idea as to the key findings.

-I recommend maintaining the same y-axis limits to all sub-plots in Figures 2-4, labelling the months on the plots for easier interpretation.

-Answer: Thanks a lot for the comments. We have responded before. We want to clarify that we did not use a uniform scale (y-axis limits). We have tried. But the temperature increasing trend for some months at some elevation groups are negative. If a uniform scale would be used, the possible range could be -1.6 to 2 ℃ $10a^{-1}$. Thus, for some months, the box plot will appear very crowded and small, which is in a poor readable for the percentile ranges (25% to 75%). Thus, we keep the different y-axis ranges. However, the referee's comment is reasonable. We figure out a good way to show the trend comparison for all month is adding a table which including all slope and significance levels. The table is as following:

Table 5. Monthly temperature trends (℃ 10a^{-1}) at different elevations based on CTMD from 1979–2016.

	Tmin	Tmean	Tmax
January	0.039***	0.036***	0.037***
February	0.033***	0.012	0.008***
March	0.023	0.009**	0.017***
April	0.021***	-0.02***	**0.069*****
May	-0.056***	-0.022***	-0.045***
June	-0.025***	0.007	-0.046***
July	0.0	-0.017**	-0.019**
August	-0.011	**0.037*****	**0.023*****
September	-0.006	**0.017****	**0.038*****
October	-0.073***	-0.018***	**0.017****
November	-0.032***	-0.031***	-0.018***
December	0.064***	**0.006****	-0.018***

Note: the bold and underlined value indicates a warming trend for higher elevations, not for the whole elevation range. More details could be found in Figure 2 to 4 and Figure S1 to S12. * denotes the significance level p<0.1, ** denotes the significance level p<0.05, and *** denotes the significance level p<0.01.

47) -For Figures 5-7, please adjust the colour scale from left (blue – negative) to right (red – positive) following the reviewer#2 comments and also set the same total scale limit for each plot (i.e. -1.5 - +1.5_C 10a-1) with 0_C trend always being the same colour (pale yellow or white). Do the authors also report trends that are not statistically significant? If so, I would also represent these as white or blank pixels if possible. This will aid the reader's ability to interpret and compare the magnitudes of trends between sub-plots/figures as well as areas that aren't statistically significant trends.

-Answer: Thanks for the suggestion. We have specially added a table to count the number of grids that at significance levels in the revision. We have revised the figures (e.g. Figure 5). However, we did not t set the not statistically significant values to white color because it affects the readability of figures.

Table 2. Ratio of sum of grids at different significance levels (p<0.1, p<0.05 and p<0.01) to total grids (356133).

	Tmin	Tmean	Tmax
January	3.28	3.65	6.48
February	9.66	0.55	56.65
March	52.02	99.35	100.00
April	3.76	69.16	46.36
May	46.97	29.21	7.63
June	80.33	92.37	49.63
July	46.86	51.97	38.82
August	35.58	56.37	40.84
September	19.87	47.77	35.32
October	11.78	25.52	11.41
November	12.00	14.07	14.12
December	0.38	0.00	0.00

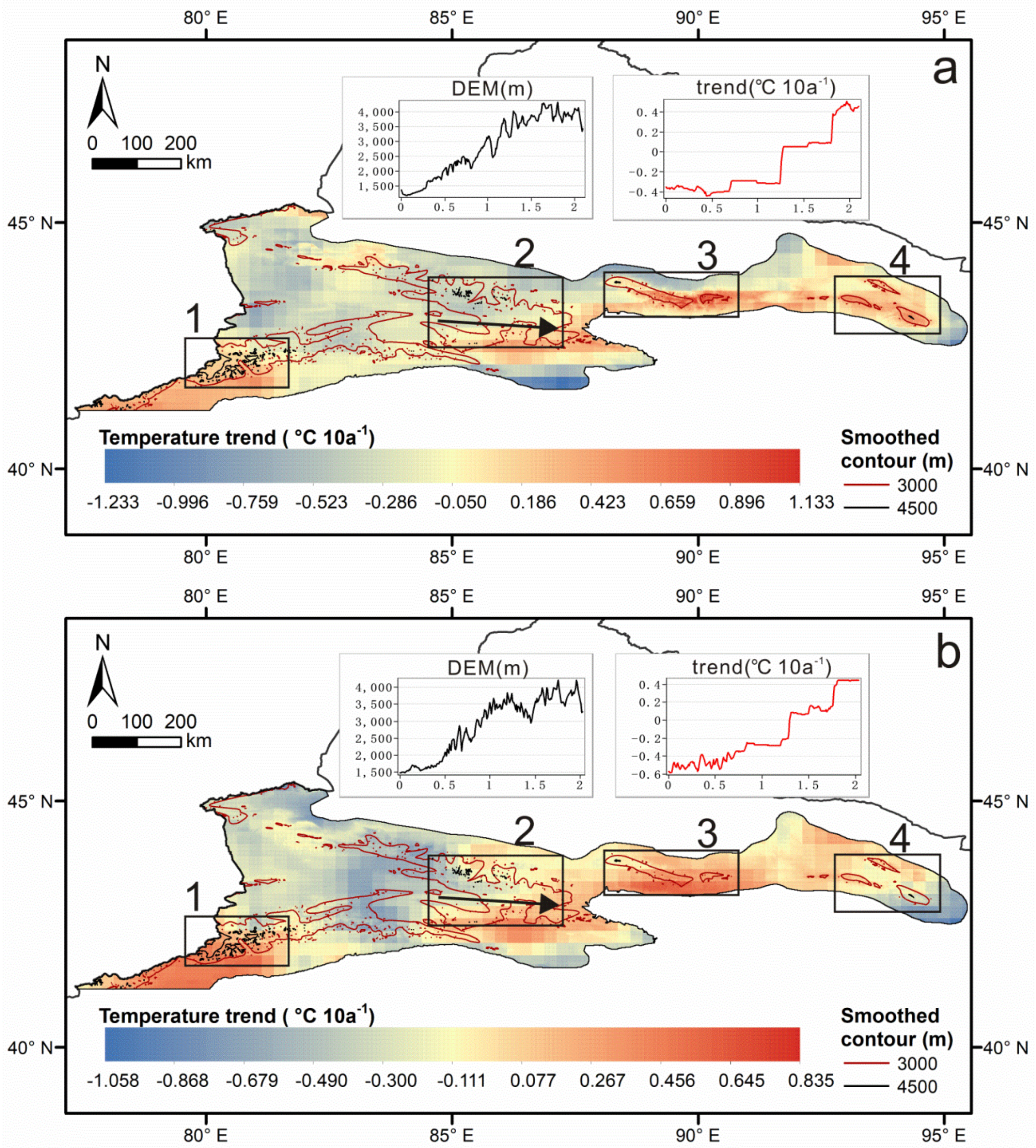

Figure 5: Monthly minimum temperature trends (a) January and (b) December for the entire CTM from 1979–2016. The ordinate of two sub-plots show the elevation trend and temperature trend along the terrain profile (black arrow indicates the direction) in Zone 2, respectively. The abscissa represents the distance in multiples of the scale.

48) -I would suggest adding some other figure(s) that shows the interannual variability of Tmin/Tmax/Tmean for some of the highest elevation pixels so we can better interpret how the suspected EDW warming for March/April/(or month of most interest) looks compared to some lower elevations, or compared to the 'background' change of 'non-mountain' regions shown from the CMA05, if the CMA05 and CTMD are indeed comparable (see general

comment). These are the two criteria for EDW and need to be more convincingly demonstrated and discussed.

-Answer: Thanks a lot for the comments. After carefully reviewing the literatures again, we have to admit that our previous definition of EDW were a bit arbitrary. To be precise, regional warming amplification and altitude warming amplification are the two basic characteristics (or “fundamental questions” from Rangwala and Miller, 2012) of EDW. In the previous literatures, although there are many discussions on altitude warming amplification in high mountains, no literature clearly states that regional warming amplification is one of criteria for EDW. We revised this part in the revision.

The reviewer provides a very good suggestion. We added more analysis on the comparison of warming trends in high altitudes and lower elevations based on CAM05 and revised the Table 3 and 4 in the revision. For example:

Table 3. Annual and seasonal temperature trends (℃ 10a^{-1}) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTM			WCC			LCC		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
Spring	0.633 ***	0.522 ***	0.640 ***	0.557 ***	0.513 ***	0.518 ***	0.543 ***	0.498 ***	0.505 ***
Summer	0.441 ***	0.342 ***	0.266 **	0.472 ***	0.388 ***	0.378 ***	0.404 ***	0.336 ***	0.348 ***
Autumn	0.302	0.200 *	0.270	0.551 ***	0.458 ***	0.420 ***	0.506 ***	0.411 ***	0.371 ***
Winter	0.014	-0.085	0.115	0.432 ***	0.361 ***	0.327 ***	0.333 **	0.257	0.211
Annual	0.347 ***	0.245 ***	0.323 ***	0.503 ***	0.430 ***	0.411 ***	0.446 ***	0.376 ***	0.359 ***

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level p<0.1, ** denotes the significance level p<0.05, and *** denotes the significance level p<0.01.

Table 4. Monthly temperature trends (℃ 10a^{-1}) in the CTM (based on CTMD) and the whole continental China (WCC) and low-altitude areas (LCC) by excluding the CTM and the QTP from the WCC (both based on CMA05) from 1979–2016.

	CTMD			**WCC**			**LCC**		
	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax	Tmin	Tmean	Tmax
January	-0.133	-0.269	-0.235	0.343 **	0.256	0.212	0.225	0.143	0.102
February	0.313	0.177	**0.605** **	0.558 ***	0.523 ***	0.549 **	0.486 **	0.456 *	0.475 *
March	**0.835** **	**0.818** ***	**1.339** ***	0.651 ***	0.672 ***	0.752 ***	0.661 ***	0.673 ***	0.738 ***

April	0.441	**0.537** ***	**0.664** *	0.547 ***	0.522 ***	0.516 ***	0.520 ***	0.503 ***	0.508 ***
May	**0.624** **	0.211	-0.082	0.475 ***	0.345 ***	0.284 ***	0.447 ***	0.317 ***	0.270 ***
June	**0.752** ***	**0.476** ***	**0.422** ***	0.516 ***	0.390 ***	0.344 ***	0.467 ***	0.348 ***	0.320 ***
July	0.227	0.331 ***	0.28	0.472 ***	0.411 ***	0.416 ***	0.402 ***	0.343 ***	0.359 ***
August	0.342	0.217 *	0.095	0.429 ***	0.363 ***	0.375 ***	0.343 ***	0.318 ***	0.363 ***
September	0.246	0.237	0.33	0.559 ***	0.486 ***	0.495 ***	0.517 ***	0.445 ***	0.456 ***
October	0.273	0.18	0.227	0.524 ***	0.434 ***	0.398 ***	0.496 ***	0.407 ***	0.372 **
November	0.386	0.183	0.252	0.569 ***	0.455 ***	0.368 **	0.503 ***	0.381 **	0.285
December	-0.137	-0.164	-0.025	0.394 ***	0.303 **	0.219	0.287 *	0.171	0.055

Note: the bold and underlined value indicates a greater warming trend in the CTM than WCC and LCC. * denotes the significance level $p<0.1$, ** denotes the significance level $p<0.05$, and *** denotes the significance level $p<0.01$.