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Interactive comment on "Evidence for elevation-dependent warming from the Chinese Tianshan Mountains" *by* Lu Gao et al.

Anonymous Referee #2

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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 timescale. 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,

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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.

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 1 km 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

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paper.

o 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.

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

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?

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?

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.

Smaller remarks, technical comments and suggestions:

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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?

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.

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

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).

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

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

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.

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 Tian Shan in 1979–2016, Earth System Science Data, 10, 2097-2114, 2018.

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