

Interactive comment on “Characteristics of the summer atmospheric boundary layer height over the Tibetan Plateau and influential factors” by Junhui Che and Ping Zhao

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Dear reviewer,

We are grateful for your insightful comments that help us to improve this manuscript. We carefully address issues in your comments. Please see below our point-to-point responses to your specific comments.

1. Of course, authors did not bring up any discussion why the other seasons were missing in the manuscript.

Response: The TIPEX-III experiment carried out the intensive observations in the TP

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region at noon (14:00 BJT) during summer, which provide a better dataset for studying the ABL during summer. In other seasons, there are no observations at 14:00 BJT. Thus summer is selected in this study. The associated statements have been added in lines 93-100 and 116-118. In addition, a statement has been added in Summary and Discussion (in lines 402-404).

2. However, at many instances, the manuscript lacks the interpretation of the results.

Response: The original manuscript was structured to show the results in Section 3 and present physical explanations in Section 4. We have realized, based on your comments, that arrangement may result in disconnections between the results and their discussions. In the revised manuscript, we have included some interpretations and the possible physical reason analyses immediately following the results. See our response to question 16 for the specific revisions.

3. In the abstract: A big picture of the problem for the region for ABL research needs to be mentioned.

Response: According to your suggestion, we have added some statements about the existing problem for the TP ABL research in lines 9-11.

4. It is mentioned “The SBL accounts for 85% of the TP ABL” and also mentioned in the very next line, “The CBL accounts for 77% of the TP ABL” needs some clarification or needs to be rephrased. Otherwise, they contradict in general sense.

Response: Thanks. Indeed, our statements should add the time frame to avoid any possible misunderstanding. According to your comments, we have changed (in lines 19-23).

5. The ABL height exhibits a large west-east difference, with a mean height above 2000 m in the western TP and around 1500 m in the eastern TP” Did you refer to the daytime well-mixed CBL here?

Response: It is due to our unclear statement. This sentence is for ABL not only for

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CBL (in line 21).

6. In the numbers, authors need to mention whether this is m AGL or m MSL. Since spatial variability is mentioned underlying orography will play a role if these numbers are in MSL. Please clarify.

Response: It is m above ground level (AGL). Following your suggestion, we have changed "m" to "m AGL" in the revised manuscript.

7. Line 30: "ABL height in climate prediction". Authors need to bring an appropriate reference here. There is only one study that directly refers to climate projection. Please refer to the following one: "Differences in the efficacy of climate forcings explained by variations in atmospheric boundary layer depth"

Response: We have added the associated references on the ABL height in climate prediction (in lines 37-38).

References:

Garratt, J. R., 1993: Sensitivity of climate simulations to land-surface and atmospheric boundary-layer treatments—A review. *J. Climate*, 6, 419–448.

Esau, I., and S. Zilitinkevich, 2010: On the role of the planetary boundary layer depth in the climate system. *Adv. Sci. Res.*, 4, 63–69.

Davy, R., and I. Esau, 2016: Differences in the efficacy of climate forcings explained by variations in atmospheric boundary layer depth. *Nat. Commun.*, 7, 11690.

8. Line 41: "The ABL height can be calculated from temperature, humidity, and wind profiles (Seibert et al., 2000; Seidel et al., 2010; Davy, 2018)." Please add a reference for numerical simulation as well since researchers are using models as well for this purpose.

Response: We have added the following references for numerical simulation (in lines 63-64).

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References:

Holtslag, B. and B. A. Boville, 1993: Local versus nonlocal boundary-layer diffusion in a global climate model. *J. Climate*, 6, 1825–1842.

Bosveld, F. C., and Coauthors, 2014b: The third GABLIS intercomparison case for evaluation studies of boundary-layer models. Part B: Results and process understanding. *Bound-Layer Meteor.*, 152, 157–187.

9. Line 48: "solar altitude angle with respect to latitude" Please refer to Seidel et al., 2010.

Response: We have changed (in lines 68-70).

10. Line 69: "result has certain limitations" What are those? Please be specific here.

Response: According to another reviewer's suggestion, we have changed "Thus, the statistical representation of their results is limited" (in line 91).

11. Line 94: Quality check

Response: It is due to our mistake. We have changed to "quality control" (in line 119).

12. Line 108: "operational observation of total cloudiness" Are these from reanalysis or from ceilometers?

Response: It is the manual ground-based cloud cover observations from the China Meteorological Administration, and has been used to analyze the relationship between the ABL height and cloud cover in China by Guo et al. (2016) and Zhang et al. (2017). The associated statements are seen in lines 132-134.

References:

Guo, J. P., Miao, Y. C., Zhang, Y., Liu, H., Li, Z. Q., Zhang, W. C., He, J., Lou, M. Y., Yan, Y., Bian, L. G., Zhai, P. M.: The climatology of planetary boundary layer height in China derived from radiosonde and reanalysis data, *Atmospheric Chemistry and*

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Zhang, W., Guo, J., Miao, Y., Liu, H., Yang, S., Fang, Z., He, J., Lou, M. Y., Yan, Y., Li, Y., Zhai, P. M.: On the summertime planetary boundary layer with different thermodynamic stability in China: a radiosonde perspective, Journal of Climate., 31, doi: 10.1175/jcli-d-17-0231.1, 2017.

13. Line 150: "This west-east difference increases from noon to the late afternoon." Authors need to bring the concept of west-to-east march of the solar timing given span of 20 deg longitude would cause some "real" solar timing issue although in the region there is no time zone separations and BJT is used here. According to classical rule of "15 degrees of longitude per hour", it will result in at least local time difference of 80 minutes or little more from western site to eastern site. Thus, the increase in the west-east gradient is also attributed to some extent to this "real" local timing differences. See Seidel et al. 2010 and other relevant studies as well. Additionally, authors need to acknowledge the above-mentioned topic in other discussion where they brought up the west-east gradient changes from noon to late afternoon.

Response: We agree with you that the increase in the west-east gradient of ABLH (including CBL height and NBL height) from noon to the late afternoon is also attributed to some extent to the "real" local timing differences. According to Seidel et al. (2010, 2012) and Guo et al. (2016), in the revised manuscript, we have added an explanation for the increasing west-east difference of the ABLH over the TP from noon to the late afternoon (in lines 205-210).

In addition, the phenomenon of "the SBL/CBL mainly occurring in the ETP/WTP at 20:00 BJT" is also related to the above-mentioned topic. In the revised manuscript, we have added an explanation, that is, the above results are consistent with the diurnal development of the ABL structure including the SBL in the early morning, the CBL at noon, and different types of ABLs between the eastern and western TP in the late afternoon because of the latitudinal difference and the resultant difference in local solar

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times. Note that the observations were made simultaneously for all stations. The associated statements are seen in lines 230-233.

14. Figure 3a-c shows the spatial distribution of the SBL height" How did they classify SBL regime during daytime soundings? Please clarify.

Response: The definition of the daytime SBL height is the same as that of the nighttime SBL in Section 2.2. In this revision, we have given the identification method of SBL in detail, the corresponding diagram of SBL, and an example (in lines 137-150, 167-172, and Fig. 2).

15. "remarkable diurnal variation." This is a qualitative statement unless some other SBL regimes are referred here for the contrasting scenario since SBL variability is in general low. Did you refer to the spatial variability? Please justify the causes for this then!

Response: We agree with you that the SBL variability is in general low, which is consistent with our results. We have changed in lines 261-263.

16. Throughout the results section, authors need to bring some discussion of the causes for these findings. Otherwise, it appears as reporting of the observed variability.

Response: Following your suggestion, we have brought some discussions of the causes in the third section. A detailed physical discussion has been given in the fourth section. The detailed statements are as follows. We have added an explanation for the regional difference of the ABLH over the TP at 14:00 BJT (in lines 196-198), an explanation for the increasing west-east difference of the ABLH over the TP from noon to the late afternoon (in lines 206-210), an explanation for the results of spatial and temporal distribution of occurrence frequency of different types of ABL (in lines 230-235), and a discussion for the results of temporal variations of all types of ABLH over the TP (in lines 254-258).

17. For section "3.2 Characteristics of SBL, NBL, and CBL heights" I will highly rec-

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ommend authors performing the analyses of ABL depth growth rates which is most appropriate parameters that they wanted to discuss mentioned in the title and the abstract. Please see the feasibility of applying estimation of daily ABL depth growth rates.

Response: According to your suggestion, we have added the growth rates of the ABLH from 08:00BJT to 14:00 BJT and from 14:00 BJT to 20:00 BJT, and added the associated statements (in lines 212-220) and Fig. 4.

18. Several discussion via the frequency distribution analyses for ETP/WTP, authors need to decide the aim of these analyses. The results are presented with respect to findings and results without taking care of their interpretations.

Response: The analyses of the frequency distribution of ABLH (Fig. 6g, h) intend to show the differences between the two regions of the TP from a different angle than the differences in the mean ABLH shown in Fig. 7. This discussion focused on the most frequently observed ABLH and how these most common ABLH varied gradually from EPT to WPT. It is true that we have not included much physical interpretation here. However, discussions are added later when the boundary layer forcing factors are discussed in section 4. The text has been modified to make our objectives of the discussion clear (in lines 271-277).

19. Interpretation part. Line 23: "when SHF is strong, the turbulent motion is strong and the ABL height develops" True in general. What about the lag of ABL development since a number of studies showed that even after SHF attains its maximum daytime value, ABL depth growth continues till the time of early evening transitions. I would like to see some results in this respect between ETP and WTP and that will clearly illustrate the differences in the surface forcings the authors have tried to engage the readers.

Response: Thanks for your comments. Following your opinions, we have added the analysis of diurnal variations of SHF and ABLH. The associated statements are seen in lines 318-325.

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20. Finally, authors should consider that some comparisons with regional scale variability of ABL depths (m MSL or m AGL, be consistent) should be presented and main conclusions why this study makes an unique contribution to the field emphasizing the new processes learned for very deep ABL over the region as reported in a number of past studies.

Response: As we understand for this question, we have compared the regional variability of the ABLH in TP with the other regional variability of the ABLH such as in the United States (Seidel et al., 2012) and in China (Guo et al., 2016) in the discussion (in lines 370-375 and 395-400), and also have explicitly stated the unique contribution of this study to the ABL in the TP (in lines 393-395).

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-787>, 2020.

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