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Reply on RC1

Xiangde Xu et al.

Author comment on "A vertical transport window of water vapor in the troposphere over the Tibetan Plateau with implications for global climate change" by Xiangde Xu et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-697-AC1, 2021

Reply to Referee 1

We are grateful to the referee for the encouraging comments and careful reviews which helped to improve the quality of our paper. In the followings we quoted each review question in the square brackets and presented our response after each paragraph.

[Review Comment: The manuscript revealed the forcing mechanism forming the vertical transport window of water vapor in the troposphere on the TP. It characterizes a window of water vapor vertical transport within the troposphere over the TP and the implication for global change. This work is very meaningful and the paper has been well-written. I therefore recommend this paper resubmitted after minor revisions.]

Reply: Thank you for the encouraging comments.

[1. Figure 1b is about the frequency of the correlation coefficients passing the level of 90% confidence between summertime TP's low cloud cover and the water vapor at different vertical levels. How do authors get the frequency? Please give the specific introduction of it.]

Reply: Frequency here refers to the number of points passing the significance test on the same latitude between 60°E - 180°E .

- Figures 2b and 2c are the spatial distributions of lag correlation coefficients. From the caption and related analysis, I didn't get the meaning of lag correlation coefficients. In the result section, there is no any analysis and discussion about the Figures 2b and 2c. Please add more illustration and discussion.]

Reply: Sorry about the description of lag correlation coefficients. Figure 2b and 2c show the spatial distributions of correlation coefficients of low cloud cover over the TP and the global specific humidity in the same month in summer (June, July and August separately) from 1979 to 2018 at (b) 400 hPa and (c) 500 hPa. We have rewritten the

description and added the illustration in the manuscript as follow:

"The vertical section of the correlation coefficients along the south-north direction between the low cloud cover on the TP and the global water vapor are presented in Figure 1b. The obviously upward movement of water vapor over the AWT can be seen in Figure 2a. It could be noticed that there exist the structures similar with the massive chimney between the convective cloud and the water vapor on the TP. Figure 2b and 2c show significant correlation between convective clouds over the AWT and water vapor over the region. Such a significant correlation began to extend southward and northward at 400~500hPa. It is remarkable that the high correlation areas exceeding the 90% confidence level expand towards the polar regions of both the southern and the northern hemispheres (Figure 1b), and the relation between the convective clouds and the global water vapor in the upper troposphere across the northern and southern hemispheres could be depicted. "

- As seen from Figure 4, it contains lots of information, but the related analysis is too simply. Please add more analysis and discussions.]

Reply: We added two subgraphs in Figure 4,which can be seen in the supplement material. The description was adjusted as follow:

"Figure 4. The vertical sections of vertical motion (contours, in unit: 10-2Pa·s^{-1}) and average Q1(shaded, in unit:10^{-3}w/kg)(a,d) ;vertical motion (contours, in unit: 10^{-2}Pa·s^{-1}) and correlation coefficients (shaded) between Q1 and the vorticity (b,e) as well as the correlation coefficients between Q1 and the divergence (c,f) separately in the core region of the AWT, in which, a, b, c is along 32 °N, and d, e, f is along 95 °E. The green triangle is the AWT."

We have added the analysis in the manuscript as follow:

" Through the correlation analysis of the whole layer of apparent heat source Q1 over the plateau region, the three-dimensional structure of vorticity and divergence, it can be found that the apparent heat source Q1 in the TP is an important forcing factor (Figure 4). The AWT is located in the mid-high level at 300-500 hPa, which is regarded as the extreme apparent heat source Q1 area, and it is significantly related to the convective cloud and its strong ascending movement□Figure 4a,d). Figure 4b,c,e and f show the correlation between the total apparent heat source Q1 in AWT and divergence/vorticity fields, which can describe the effective "suction effect" that displays the configuration with divergence (negative vorticity) at the upper levels and convergence (positive vorticity) at lower levels. The Q1 is significantly related to the convective cloud and its strong ascending movement, and there exists a strong high-level anticyclone in the region of the AWT in the southeast of the plateau (Figure 3d). In addition, the lower troposphere is the center of strong convergence and strong vorticity. All these results reveal the effective "pumping effect" of the vertical configuration with low-level cyclonic circulation and high-level divergence with anticyclone circulation in the TP (Figure 4b,c,e,f). The strong confluence effect could be driven by the elevated heating on the TP in the middle troposphere with the water vapor flow, making a strong warm wet vapor transport channel connecting the water vapor source in the low latitude tropical ocean with the water vapor center over the core area of AWT. "

- 4~9. L70, tropophere-> troposphere

L88, 100hpa--> 100 hPa

L307, 60oE - 180oE--> 60oE - 180oE

L142, the Asian water tower (AWT) --> AWT

L149, Figure 3c should be Figure 3b

L150, Figure 3d should be Figure 3c.]

Reply: Following this comment, we have adjusted it as required.

- P17,what does the shading mean in Figures 3b,c and d? What's the difference between Figure 3d and Figures 3b and c? The correlation in Figures 3b and c are based on the period of 1979-2016, aren't they? And why the correlation based on the period of 2014-2016 are given in particular?]

Reply: The shaded parts in Figure 3b and 3c indicate correlation coefficients of TP-column Q1 integrated to water vapor. The correlation coefficient in Figure 3d exceeds the significant test at the 90% and more confidence level.

The order of subgraphs in Figure 3 has been changed, which can be seen in the supplement material and the descriptions are adjusted as follow:

" (a) The spatial distributions of correlation coefficients of low cloud cover over the TP with the global specific humidity of the ECMWF-interim data at 300 hPa in summers of 1979-2016 with the pathways of convective air to the troposphere, (b) correlation vectors of TP-column Q1 integrated over the TP region (80-102^{o}E; 30-37.5^{o}N) to 300hPa vapor transport flux in July 2014-2016. The shaded area indicates the correlation coefficient exceeds the significant test at the 90% confidence level; the correlation field between the total apparent heat source Q1 over the TP region (80-102^{o}E; 30-37.5^{o}N) with the water vapor (shaded) and water vapor flux (stream lines) in the surface layer (c) and middle layer (500hpa) (d) in summer over 1979-2015, respectively. "

The correlation mentioned in Figures. 3c and 3d is based on monthly mean Q1 and water vapor flux during 1979-2015 in summer. While Figure 3b shows correlation between daily mean Q1 in TP and water vapor flux in July from 2014 to 2016 at 300hPa so as to discuss the driving effect of Q1 on water vapor transport at the synoptic system and process scale in the Plateau region.

We have supplemented the illustration in the manuscript as follow:

"Figure 3b shows the correlation between daily mean Q1 in the TP and water vapor flux in July from 2014 to 2016 at 300hPa so as to discuss the driving effect of Q1 on water vapor transport at the synoptic system and process scale in the Plateau region. From the perspective of daily weather process in July of 2014-2016, the possible mechanism of the global effect of 300hpa anticyclone on water vapor transport is revealed. There exists also a strong high-level anticyclone in the region of the AWT in the southeast of the plateau, which takes a significant part in the exchange of water vapor between the troposphere and stratosphere (Garny, et al., 2016;Fu, et al., 2006) ."

- P18, the caption makes reader confused. All the contours in these four figures

represent the vertical motion, not just in (a). Please rewrite the description of these four subgraphs.]

Following this comment, we have adjusted it as required.

"Figure 4. The vertical sections of vertical motion (contours, in unit: 10-2Pa·s-1) and average Q1(shaded, in unit:10-3w/kg)(a,d) ;vertical motion (contours, in unit: 10-2Pa·s-1) and correlation coefficients (shaded) between Q1 and the vorticity (b,e) as well as the correlation coefficients between Q1 and the divergence (c,f) separately in the core region of the AWT, in which, a, b, c is along 32 °N, and d, e, f is along 95 °E. The green triangle is the AWT."

Please also note the supplement to this comment:
https://acp.copernicus.org/preprints/acp-2021-697/acp-2021-697-AC1-supplement.pdf