Dear Dr. Smith,

Please find our revised manuscript "A Model Framework on Atmosphere-snow Water vapor Exchange and the Associated Isotope Effects at Dome Argus, Antarctica: Part I the Diurnal Changes " by Ma et al. We really appreciate that you take the time to handle this manuscript. We have received comments from three new reviewers, and you can see they are all relatively minor. In the revised manuscript, we have addressed all the comments and made corresponding changes/corrections.

The revisions to the manuscript were concentrated on three key areas: 1) incorporating a comparison of the estimated initial snow isotopic composition (Section 2.2.3 and Supplementary); 2) providing additional details in the determination of water vapor isotopic composition in the free atmosphere layer (Section 2.2.1); and 3) discussing the suitability of continuous simulations at Dome A (Section 4).

In addition, we have undertaken a thorough language revision of the manuscript and corrected other writing errors. We hope these efforts will further improve manuscript.

We confirm that this manuscript has not been published elsewhere and is not under consideration by another journal. All authors have approved the manuscript and agree with its submission to The Cryosphere. Please address all correspondence to genglei@ustc.edu.cn. We look forward to hearing from you at your earliest convenience.

Sincerely,

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Response to Referee #1/Report #4's comments

1) Line 105: Think that this should be clouds vs cloud

Response: Thanks, we used 'clouds' to replace 'cloud' in this sentence.

2) Figure 1: why dotted lines on arrows in deposition column?

Response: Thank you. During deposition, water vapor exchange between the boundary layer and free atmosphere only occurs when $Ri < 0.1$ (i.e., the unstable condition for atmospheric layer). In comparison, this process can consistently take place during the sublimation phase when the atmospheric conditions remain unstable throughout the daytime and warming periods. In order to highlight the difference, we used the dotted arrows with a label ($Ri < 0.1$) to indicate that this exchange only occurs when $Ri < 0$. To make it more clear, we have added an explanatory sentence in the title of Figure 1 in the revised manuscript.

3) Line 177, Eqn 8, define variable S

Response: S is the unit area. We have added a definition of S in the main text and supplementary.

4) Line 304: The comparison of the estimation based on the Pang et al data should be presented, as should the estimation of the initial snow isotopic composition from the ECHAM5 model, given the sensitivity to this parameter.

Response: We are really grateful to the reviewer for the rigorous considerations. The comparison between the estimation the of initial snow isotopic composition based on the Pang et al. (2019) data and the ECHAM5 model has already been addressed in our previous response to Reviewer #2. The results were shown in Figure 1 of this response. We put this figure into the supplementary and added one sentence to describe it in the main texts.

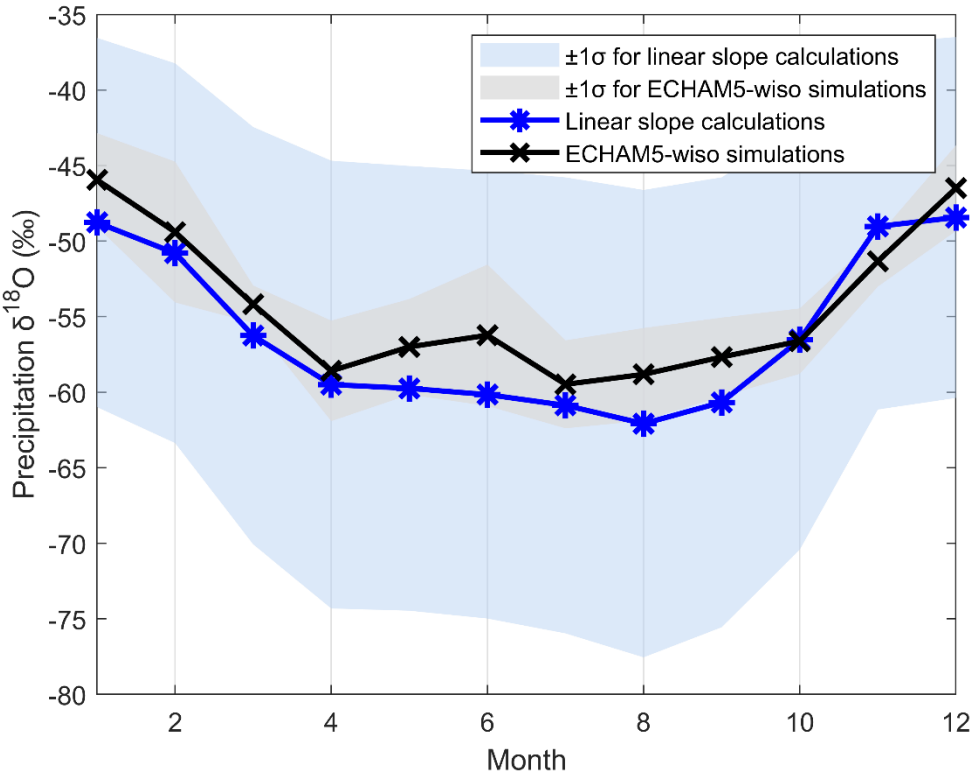

Figure 1. The estimated precipitation $\delta^{18}O$ and its standard deviation during the period of 2005-2011. Blue solid line with star marks represents the calculations using the temperature-isotope slope according to data from Pang et al. (2019), and the light blue shaded area is the uncertainties. Black solid line with x marks and light grey shaded area displays the ECHAM5-wiso simulation data and its uncertainties, respectively.

End of Response to Referee #1

Response to Referee #2/Report #5's comments

1) Line 85, "box model." changes to 'box model'.

Response: Thanks, the superfluous full stop was deleted from this sentence.

2) Line 99-100, the authors indicate that at Dome A the time interval between two precipitation events can reach ~80 days. Please give a reference here.

Response: Thank you. This statement is based on the ERA-5 dataset since there are no observations at Dome A. In the revised manuscript, we have stated the data sources at the end of this sentence. The details are follows:

In addition, reanalysis data indicate that at Dome A the time interval between two precipitation events can reach ~ 80 days (estimated based on ERA5 reanalysis dataset), which means that snow can sit at the surface for a substantially long period before burial, and is subject to experience extensive atmosphere-snow water vapor exchange, which consequently affects the isotopic composition of the buried snow.

3) Line 235-237, the authors indicate that the isotopic composition of vapor in the free atmosphere layer (δf0) is greater than the isotopic composition of vapor in the boundary layer (δv0). This is due to the contribution from the free atmosphere can increase the ratio of H218O molecules in the boundary layer (Casado et al., 2018). Why the contribution from the free atmosphere can increase the ratio of H218O molecules in the boundary layer? The authors should explain it in more details.

Response: Thanks for this question. Based on the vertical isotopic profiles ($\delta^{18}O$) observed at the summit of Greenland (Berkelhammer et al., 2016), it is noted that the isotopic composition of water vapor in the free atmosphere adjacent to the boundary layer is nearly equivalent to, or only slightly greater than, that within the boundary layer throughout the entire year (Figure 2 of this response). Although there are currently no vertical observations of water vapor isotopic composition in central Antarctica, Casado et al. (2018) assumed that this feature may be universally present in polar inland regions. With assumption, Casado et al. (2018) found that the water vapor and snow isotopic compositions under the influence of exchange with the free atmosphere at Dome C can be explained. In this study, we followed the same assumption and considered that the isotopic composition of water vapor in the free atmosphere is higher than that within the boundary layer at Dome A.

In the revised manuscript, we have made this more clear in Section 2.2.1:

Here we expect that δf0 is greater than δv0. Although there are currently no vertical observations of water vapor isotopic composition in Antarctica, vertical isotopic profiles ($\delta^{18}O$) observed at the summit of Greenland have indicated that the isotopic composition of water vapor in the free atmosphere is slightly higher than that within the boundary layer (Berkelhammer et al., 2016). In order to explain the water vapor and snow isotope observations at Dome C, Casado et al. (2018) assumed that the contribution from the free atmosphere can increase the ratio of $H_2{}^{18}O$ molecules in the boundary layer (Casado et al., 2018) and set δf0 as the highest observed value of water vapor isotopic composition at Dome C.

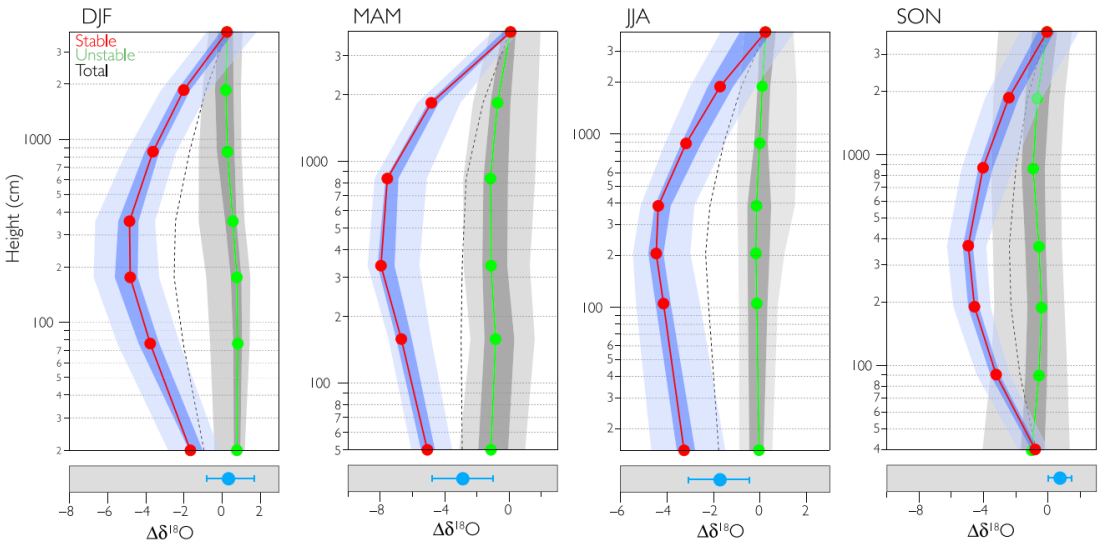

Figure 2. Vertical profiles of the isotopic ratio ($\delta^{18}O$) at Summit Camp, Greenland (Cited from Berkelhammer et al., 2016).

4) Line 237, 'Casado et al. 2018' should be 'Casado et al., 2018'.
Response: Thanks, correct.

5) Line 410-411, the authors indicate that as δ18Os0 decreases, the magnitude of δ18Os diurnal changes decreases. But in Fig. 8e, we can see that as δ18Os0 decreases, the magnitude of δ18Os diurnal changes increases (not decrease). Is that right?
Response: Thanks for pointing out this issue. We have overlooked the pattern and a comment by the reviewer, the correct trend is that the magnitude of $\delta^{18}O_s$ diurnal changes increases as the $\delta^{18}Os_0$ decreases. In the revised manuscript, we have corrected the description in this sentence.

6) Line 426, 'Fig. 2, 4c, and 5c' should be 'Figs. 2, 4c, and 5c'.
Response: Thanks, correct.

7) Line 449, 'data from Dome A simulations' changes to 'data at Dome A'.
Response: Correct.

8) Line 526, 'by those in summer' changes to 'by those in winter'; 'snow isotopes." changes to 'snow isotopes.'.
Response: Thanks, correct.

End of Response to Referee #2

Response to Referee #3/Anonymous reviewer #2's comments

1) Figure 7: The authors kindly provided a continuous simulation at Dome A. However, this simulation looks considerably different from the continuous simulation at Dome C presented in Figure 3e. In particular, the large variations in the vapor isotopic composition seem unrealistic and I would like to ask the authors to check and explain what causes these large variations and comment on the appropriateness of using this vapor data for the Dome A simulations in the manuscript's discussion.

Response: Thank you. The significant fluctuations observed in the modeled vapor isotopic composition at Dome A are primarily attributed to abrupt shifts in temperature measurements. Upon re-evaluation, we noted that substantial variations in water vapor isotopes can arise when temperature changes exceed 5°C within a given time interval (1 hour). Such marked temperature fluctuations can profoundly impact atmospheric conditions and the isotopic fractionation coefficient. Although these changes may result in only minor variations in the snow layer due to its large reservoir of water molecules, they can significantly affect the isotopic composition of water vapor. Furthermore, we did not separate clear-sky and cloudy conditions during continuous simulations at Dome A. This simplified parameterization is likely to enhance the variability of our calculated results. In the revised manuscript, we added the statement in the deficient of continuous simulation.

However, it should be noted that the continuous simulation in this study was conducted without differentiating between clear-sky and cloudy conditions and was considerably affected by abrupt temperature fluctuations observed at Dome A. Therefore, further exploration of continuous simulations is required, which can be achieved through improvements in model refinement and the capabilities of observational techniques with more precise data available.

2) L. 331: Please correct to ECHAM5-wiso.

Response: Thanks, correct.

3) L. 468: As the authors suggested in response to reviewers, I suggest to reference Fig. 2, 4c, d and 5c, d, since Fig. 2, 4c, and 5c do not show isotopic values and, thus, do not sufficiently support the statement. The referenced Figures in the manuscript differ from the response to the reviewers.

Response: Thanks for this advice. We agree that the relationship between meteorological factors and simulations in water isotopes needs to be demonstrated by 5 figures, namely Figs. 2, 4c, 4d, 5c, and 5d, instead of only the 3 figures mentioned in the original manuscript. We have made correspondingly revisions in the main text.

4) L. 524: As mentioned in a previous reviewer's comment, Figures 4 and 5 show no general vapor depletion in summer. I suggest removing the second part of this sentence. The authors indicated in the response to the reviewers that they agree with removing this line, however, the lines are not removed in the uploaded manuscript.

Response: Thanks, delete.

End of Response to Referee #3

Reference

Berkelhammer, M., Noone, D. C., Steen-Larsen, H. C., Bailey, A., Cox, C. J., O'Neill, M. S., Schneider, D., Steffen, K., and White, J. W. C.: Surface-atmosphere decoupling limits accumulation at Summit, Greenland, Science Advance, 2, e1501704, doi: 10.1126/sciadv.1501704, 2016.

Casado, M., Landais, A., Picard, G., Münch, T., Laepple, T., Stenni, B., et al.: Archival processes of the water stable isotope signal in East Antarctic ice cores, The Cryosphere, 12(5), 1745-1766, doi: 10.5194/tc-12-1745-2018, 2018.

Pang, H., Hou, S., Landais, A., Masson-Delmotte, V., Jouzel, J., Steen-Larsen, H. C.: Influence of Summer Sublimation on δD, δ18O, and δ17O in Precipitation, East Antarctica, and Implications for Climate Reconstruction from Ice Cores, Journal of Geophysical Research: Atmospheres, 124(13), 7339-7358, doi: 10.1029/2018JD030218, 2019.