Responses to Comments on the Manuscript:

"Water vapor isotopes indicating rapid shift among multiple moisture sources for the 2018/2019 winter extreme precipitation events in Southeast China"

(MS No.: hess-2021-269)

Many thanks for the reviewer's constructive comments. Below are our point-to-point responses to the comments. The comments are in black, and our responses are in blue.

General comments:

Through isotope observation data and HYSPLIT model simulation, this study reveals the close relationship between isotope changes and different water vapor sources, and clearly shows the rapid movement of water vapor source area through d-excess, which provides a certain theoretical basis for in-depth analysis of water vapor source path and water vapor supply in extreme precipitation area. Although there are still some shortcomings in this paper, I suggest that this paper be revised and published on HESS.

Specific comments,

1) L.73 'above sea level' can be abbreviated as 'a.s.l.'.

Response: Change has been made accordingly in the revision.

2) L.78-80 How to define extreme precipitation in this paper? What standards are used?

Response: In the 2018/2019 winter, the regional average cumulative effective precipitation days in Southeast China exceeded 51 days, breaking the historical record since 1981 (Guo et al., 2019). In Nanjing, where our research site is located, the accumulated precipitation is 259 mm, more than double the seasonal average of 1981–2010. As a result, we defined the 2018/2019 winter as a typical long-term extreme precipitation period. Because some water vapor isotopic data at Nanjing were missing due to instrument repair or maintenance, five large-scale precipitation events were finally selected for analysis, including (a) December 4−11, (b) December 24−30, 2018, (c) January 7−11, (d) February 16−22, and (e) January 27−31, 2019. We added the definition of winter extreme precipitation in new **Section 2.5**.

3) There are six extreme precipitation indexes (WMO). Which indexes are studied in this study? The reviewers believe that the relationship between precipitation events, precipitation intensity and stable isotopes should be analyzed respectively;

Response: In the 2018/2019 winter, the regional average cumulative effective precipitation days in Southeast China exceeded 51 days, breaking the historical record since 1981 (Guo et al., 2019). In Nanjing, the accumulated precipitation is 259 mm, more than double the seasonal average of 1981–2010. As a result, we defined the 2018/2019 winter as a typical long-term extreme precipitation period.

We agree with the reviewer that the relationship between precipitation events, precipitation intensity and stable isotopes should be analyzed respectively. In this study, we analyzed the relationship between five extreme precipitation events and stable isotopes in water vapor. Based on the large-scale atmospheric circulation patterns, we group these precipitation events into three classes: 1) the cold air mass dominated events, 2) the warm air mass dominated events, and 3) the alternating cold and warm air masses dominated events. Correspondingly, water vapor isotopes also show three kinds of variation characteristics. In the first class, the $\delta^{18}O_v$ value was generally high at the beginning, decreased significantly during the events, and gradually increased again toward the end of the events, whereas the d_v value showed the opposite trends. In the second class, the $\delta^{18}O_v$ value was generally high at the beginning, decreased significantly during the events, and gradually increased again toward the end of the events. Different from the first class, both $\delta^{18}O_v$ and d_v values in this class showed changes in the same direction throughout the event. In the third class, the $\delta^{18}O_v$ value remained constant in the early stage, and decreased rapidly in the later stage, while the d_v value fluctuated greatly. It is clear that the impacts of different atmospheric circulation systems on water vapor isotopes differ significant.

According to the reviewer's suggestion, we analyzed the relationship between precipitation intensity and stable isotopes, as shown in Figure R1. Overall, no significant correlations were observed for all events. There are only weak negative correlations in some events (Figs. R1c, d, and e), indicating that precipitation intensity is not the dominant factor affecting stable isotopes in water vapor. However, precipitation amount can influence water vapor isotopes during some stages of precipitation events (i.e., stage 4 of event a, stage 1 of event c and d, stage 2 of event e), which was analyzed in new **Section 4.1** "Controlling factors for water vapor isotopic variations during precipitation events".

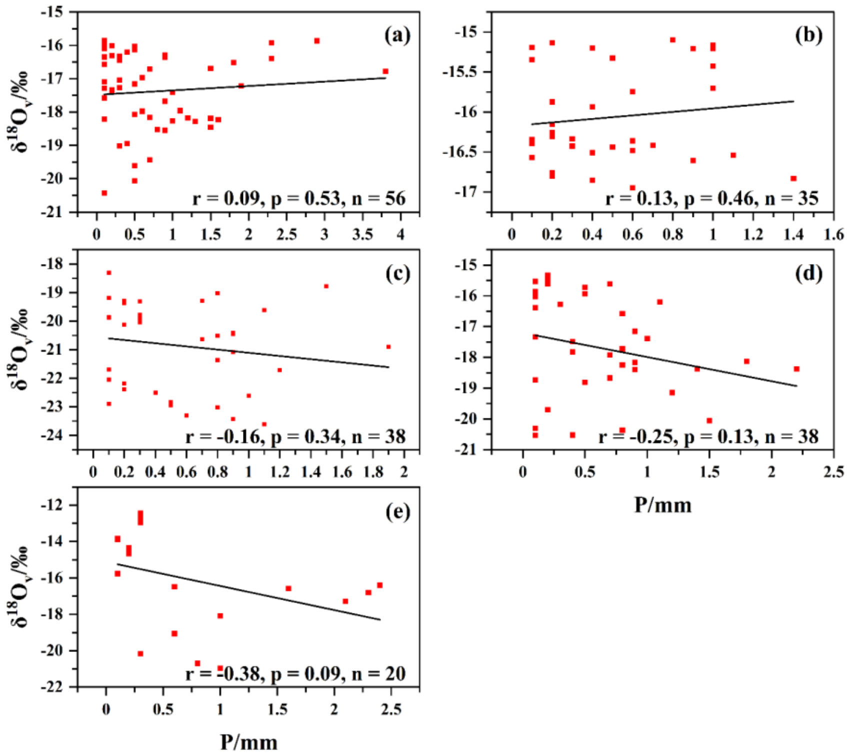

Figure R1. The bivariate plots between hourly $\delta^{18}O_v$ and precipitation amount (P) for the five extreme precipitation events. (a) Event December 4–11, 2018; (b) Event December 24–30, 2018; (c) Event January 7–11, 2019; (d) Event February 16–22, 2019; (e) Event January 27–31, 2019. Lines represent the linear regression relationship.

4) How long did the HYSPLIT backward trajectory mode simulation track?

Response: In this study, the backward trajectory was simulated for 192 hours (8 days) because the average residence time of water vapor in the atmosphere is about 8 to 10 days (van der Ent and Tuinenburg, 2017).

5) The typical reason for the formation of cold wave in winter is the complex weather in 2018/2019. In addition to sufficient water vapor conditions and circulation field, atmospheric stability is also a necessary condition for the formation of extreme precipitation events. The analysis of atmospheric stability is lack in this paper

Response: We agree with the reviewer. Hourly atmospheric stability has been calculated and added to **Figure 2** in the revised manuscript. We also analyzed the variations of atmospheric stability and their influence on water vapor stable isotopes in **Section 3** and new **Section 4.1**, respectively.

6) The variations in $\delta^{18}O_v$ and d_v values of water vapor have a good correspondence with wind direction, but what is the relationship with the vapor transport simulated by the HYSPLIT model?

Response: Thanks for the reviewer's comments. Figure R2 shows the comparison between the HYSPLIT backward trajectories 6 hours before the turning point of d_v (red) and the trajectories 6 hours after the turning point of d_v (blue) for the five precipitation events. In most cases, the trajectories before and after the turning point are significantly different, which further proves that the turning points of d_v correspond to the rapid shift of moisture source regions. We added these results in **Section 4.3** and supporting information.

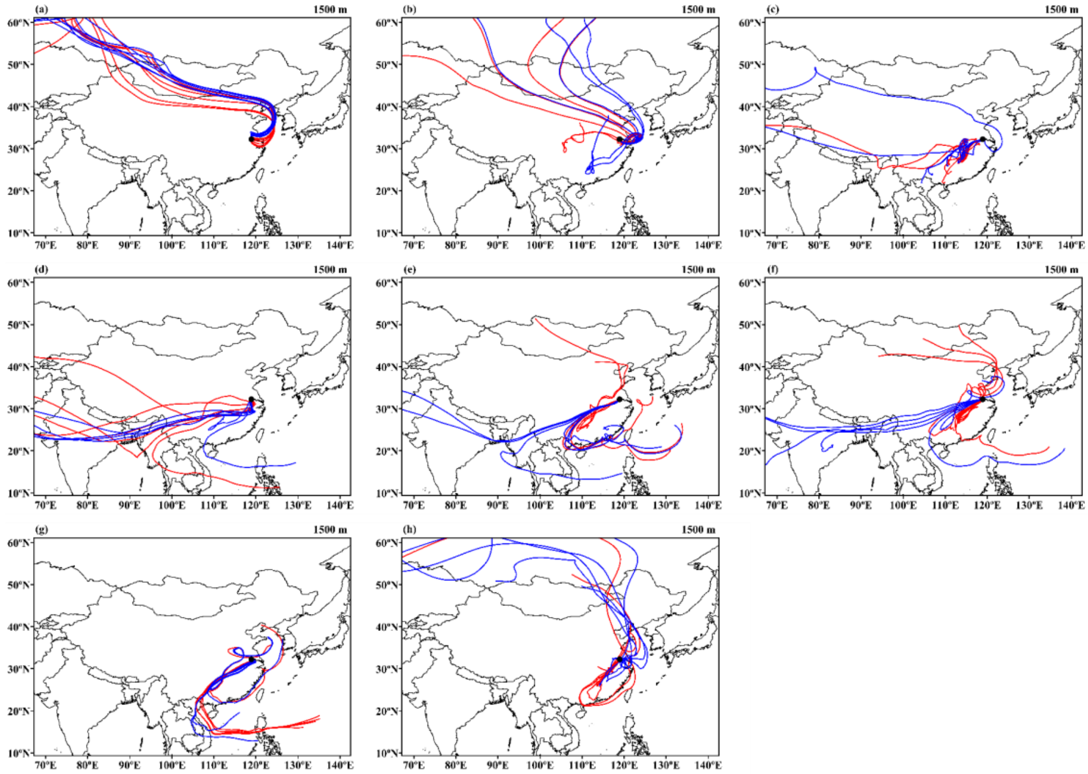

Figure R2. Spatial distribution of the selected 192 h HYSPLIT back trajectories for the five precipitation events. The red lines represent the trajectories 6 hours before the turning point of the d_v, and the blue lines represent the trajectories 6 hours after the turning point of the d_v: (a) and (b) for the d_v turning points of Event December 4−11, 2018; (c) for the d_v turning points of Event December 24−30, 2018; (d) and (e) for the d_v turning points of Event January 7−11, 2019; (f) and (g) for the d_v turning points of Event February 16−22, 2019; (h) for the d_v turning points of Event January 27−31, 2019. The black circle indicates the location of Nanjing.

7) L.118-119 '(c) January 7−11, (d) February 16−22, and (e) January 27−31, 2019'. should be '(c) January 7−11, (d) January 27−31, and (e) February 16−22, 2019'.

Response: The subplots were ordered by the three classifications, and hence not in chronological order.

References

Guo, L., Liu, B., and Zhu, C.: Extraordinary long wet spell in south of Yangtze River during 2018/2019 winter and its possible causes, Chinese. Sci. Bull., 64, 3498−3509, https://doi.org/10.1360/N972019-00357, 2019 (in Chinese with English abstract).

van der Ent, R. J. and Tuinenburg, O. A.: The residence time of water in the atmosphere revisited, Hydrol. Earth. Syst. Sci., 21, 779−790, https://doi.org/10.5194/hess-21-779-2017, 2017.