

A detailed, point-by-point response to the review comments is given below. Each review comment is repeated, followed by [our action to modify the manuscript](#). All Page and Line numbers correspond to locations in the revised manuscript.

#2 Reviewer

General comment

Using a $\delta^{18}\text{O}_p$ in daily precipitation record in Changsha for the period 01/2010 to 12/2022 as well as IsoGSM model results, ERA5 reanalyses and meteorological data, Xiao et al. investigate the water vapor transport during two extreme events in the Dongting Lake Basin: one extreme rainfall event in June 2017 and one freezing disaster in January 2008. A daily isotope record is presented, and several analyses and research methods were performed to analyze the changes in water vapor source related to these extreme events. In its topic, this paper fits the scope of the journal ACP. However, several points in the methodology and the data used are misleading, and more systematic analyses and figures of extreme events vs. climatological background are missing. Also, I am not sure to see the added value of water isotopes for better describing extreme events in the region in terms of water vapor transport and meteorological changes in the current version of this manuscript. Moreover, there are issues related to data transparency, the quality of the figures, and misleading terms, which need to be addressed. I hesitate between rejection and major revision considering I have doubts on the use of this $\delta^{18}\text{O}_p$ record for the extreme events topic. This record, as the authors said, is more adapted for seasonal and interannual variabilities, and large-scale climate processes.

[Response: We greatly appreciate your thorough assessment of our work and your candid feedback regarding the added value of stable isotope data in this extreme-event study. We recognize that the original manuscript did not sufficiently articulate the scientific rationale for applying a daily-resolution isotope record to synoptic-scale extreme events, nor did it clearly position this work relative to our previously published climatic-scale study \(Xiao et al., 2025a, Atmospheric Chemistry and Physics\). We would like to clarify the core motivation and contributions of this study as follows:](#)

[First, this work is a direct follow-up and in-depth extension of our previous climatic-scale study published in ACP in 2025. The earlier work characterized the seasonal patterns of water vapor transport pathways and their modulation of precipitation isotopes under long-term mean climatic conditions. Building on that climatic-scale framework, the present study moves to the synoptic weather scale and focuses on once-in-a-century extreme events, which is also the implication of “Revisiting” in the title. It addresses a critical follow-up scientific question: do the circulation–transport–isotope relationships derived from climatic averages remain valid under extreme, far-from-equilibrium synoptic conditions? This is a non-trivial scientific question, because extreme events involve intensified transport, enhanced](#)

condensation, and strong frontal dynamics that could potentially break the seasonal isotopic systematics. Answering this question is critical both for process understanding and for paleoclimatic applications, where sedimentary isotope records integrate both background climate and extreme-event signals.

Second, the daily-resolution precipitation isotope record is fully appropriate for this research objective. While the 13-year record was indeed originally collected for seasonal and interannual analysis, its daily sampling resolution captures the synoptic evolution of individual precipitation events. In this study, we use the isotope record for three specific purposes that cannot be achieved with dynamical reanalysis alone: (1) Independent geochemical verification of transport pathways: The progressive depletion of heavy isotopes along transport pathways follows Rayleigh fractionation theory, providing chemical evidence that the flux-based pathways identified from the Q field are actual water vapor transport corridors, not just artifacts of the wind field; (2) Quantification of isotopic perturbation intensity: We quantify how much a once-in-a-century extreme event shifts the local precipitation isotopic composition relative to its seasonal baseline. The finding that isotopic shifts are surprisingly modest ($\sim 1\text{--}1.5\text{‰}$) and the position of event samples relative to the Local Meteoric Water Line (LMWL) are key results with direct implications for paleoclimate reconstruction—it suggests that individual extreme events do not dominate long-term sedimentary isotope averages, which cannot be inferred from wind or water vapor flux data alone.

In the revised manuscript, we will strengthen the Introduction and Discussion sections to explicitly articulate these points, and we will add systematic climatological baseline comparisons for all key variables (water vapor flux, circulation patterns, and isotopic composition) to clearly highlight the anomalous character of the two extreme events. We also address all your specific concerns about data, methods, and figures in the point-by-point responses below.

Specific comments

The authors present a rather long record but finally focus only on two short events. While the precipitation event in July 2017 is quite clear in figure 2, the January 2008 freezing event does not seem so prominent compared to the rather similar low temperature in January 2019. Moreover, there is clearly no impact on $\delta^{18}\text{O}_p$ (see next point). In almost all the figures, there is no context of these events related to the climatology. Are these events really exceptional? Is there any change in water vapor transport and precipitation patterns compared to the mean state? In the current version of the paper, this is not clear. Moreover, there is a confusion between the mean water vapor transport all along these events (sections 3.2 and 3.3) and the more dynamic way using HYSPLIT.

Response: Thank you for raising this important issue of event exceptionalism and methodological clarity. We acknowledge that the original manuscript did not sufficiently quantify the extremeness of the two events nor clearly distinguish the physical meaning of the Q method and HYSPLIT method.

On the exceptional nature of the two events: The two events were selected based on multi-metric extreme rankings across the entire Dongting Lake Basin (97 meteorological stations), not just single-station temperature or precipitation at Changsha: (1) June 2017 extreme rainstorm (June 22 – July 2): This was the strongest sustained rainfall event in the basin since 1950. Across the basin, 27 stations broke their historical 10-day cumulative precipitation records, 40 stations recorded over 300 mm of 10-day rainfall (reaching severe flooding standards), and the maximum process precipitation reached 592.2 mm at Chenxi station (Kuang and Ma, 2019; Li et al., 2020). This event triggered basin-wide river and lake flooding exceeding warning levels, with several hydrological stations breaking historical records. (2) January 2008 extreme freezing event (January 12–February 8): This was the most severe low-temperature freezing disaster in the basin over the past 76 years. It set records across multiple indicators: duration of continuous freezing days (71 stations broke local records), duration of severe cold (59 stations broke records), number of snow cover days (79 stations exceeded 10 days), and maximum snow depth (up to 19 cm). In total, 74 of 97 stations reached severe freezing standards (Zhou et al., 2011). The January 2019 cold event, by comparison, was a short-duration cold surge with only 3–5 days of freezing temperatures, minimal snow cover, and far smaller spatial extent—it did not approach the once-in-a-century return level of the 2008 event.

On climatological baseline context: In the revised manuscript, we will systematically add climatological baseline comparisons: (1) In Sections 3.2.1 and 3.3.1, we will add multi-year event-average water vapor fluxes for the same calendar windows (June 22~25 and January 25~28) to quantify anomaly magnitudes. For example, Event A's total water vapor budget is ~36 times the climatological June 4-day mean, and Event B's southwest boundary flux is ~3 times the January climatological mean; (2) In Figures 3, 4, and 6, we will add climatological mean background fields (as difference maps or side-by-side panels) to visually demonstrate how the extreme-event patterns deviate from normal conditions; (3) In Table 1, we will add a row for synchronous 4-day climatological means for direct comparison.

On the Q method vs. HYSPLIT distinction: We recognize the original text confused the two methods. In the revised manuscript, we will clearly define their physical meanings and complementary roles: (1) The Q method (Eulerian flux approach): This method calculates the vertically integrated mass flux of water vapor through a given area. It represents the bulk transport of water mass across the entire atmospheric column, averaged over the event period. It answers the question: how much water vapor is moving, in what direction, and through which pathways? (2) The HYSPLIT method (Lagrangian

trajectory approach): This method tracks the movement of individual air parcels at discrete heights backward in time. It represents the motion of air particles at specific vertical levels, at specific moments in time. It answers the question: where did the air parcels at a given location and altitude come from? These two methods describe water vapor transport from fundamentally different perspectives—mass flux vs. air particle motion—and they are expected to yield different results, especially in intense frontal systems where wind direction and humidity change sharply with height. In the revised Discussion, we will explicitly explain why their differences are physically meaningful, not methodological errors.

The interest of using water isotopes and their temporal resolution is not clear in this study. First, the authors focus on 3-4 days corresponding to the maximum amplitude of the events, which means only 3-4 data points. I am not sure this is really sufficient to describe such event. Secondly, there is no clear impact on modeled and observed $\delta^{18}\text{O}_p$ (figures 2, 4, 6, 8) and no clear objective why we should use them. To check the $\delta^{18}\text{O}_p$ variations just to check their variations is not enough for such a paper. To get the water vapor source in this context, there is no need of water isotopes (HYSPLIT does the job) and there is, again, no clear change in stable isotope composition of precipitation. So, I am wondering if this record is really adapted for the extreme events topic.

Response: We appreciate this critical comment and acknowledge that the original manuscript did not adequately explain the scientific purpose of including stable isotope analysis. We would like to clarify the unique role that water isotopes play in this study, which cannot be replaced by HYSPLIT trajectory analysis alone.

First, regarding temporal resolution: our analysis uses both daily observed isotopes from station records and 6-hourly simulated isotopes from isoGSM. The 4-day peak period therefore provides 4 daily observational points and 16 6-hourly model points, which is sufficient to characterize event-averaged isotopic signatures. More importantly, our research goal is not to resolve sub-daily isotopic fluctuations, but to determine whether the event-integrated isotopic composition deviates systematically from seasonal baselines, and whether along-path isotopic gradients follow expected fractionation laws.

Second, water isotopes provide two unique insights that HYSPLIT cannot deliver: (1) Geochemical validation of transport pathway identity: HYSPLIT only tracks air movement based on wind fields; it cannot confirm whether the tracked air parcels are actually the source of the water vapor that falls as precipitation. Isotopic gradients along transport pathways are controlled by a combination of Rayleigh fractionation and moisture budget effects (i.e., the water balance principles). As water vapor is progressively removed via rainfall and replenished through moisture convergence, the observed $\delta^{18}\text{O}$

systematically decreases along each identified pathway, offering independent chemical evidence that these are indeed active water vapor transport corridors feeding basin precipitation. (2) Partitioning of source vs. rainout effects: A fundamental question in isotope hydrometeorology is whether isotopic changes during an event arise from shifts in water vapor source or variations in condensation and moisture budget along transport paths.

Third, we also clarify two common misconceptions regarding water vapor transport to support this partitioning: (a) Distinction between water vapor transport and monsoon circulation: Monsoon circulation is driven by sea-land thermal contrast, and its characteristic wind pattern is mainly confined to the middle and lower troposphere; the monsoon signature weakens significantly in the upper troposphere where planetary wind systems dominate. Water vapor transport, by contrast, is a vertically integrated quantity spanning from the near-surface layer up to approximately 300 hPa. Therefore, near-surface monsoon circulation cannot simply represent the direction or magnitude of total-column water vapor transport. On synoptic timescales, especially during extreme events, the pathway and flux of total water vapor transport can deviate substantially from seasonal mean monsoon patterns. (b) Isotopic signatures of water vapor on weather scales: We clarify a widely held misperception on this point. It is often assumed that water vapor from low-latitude oceans is isotopically depleted while water vapor from inland sources is isotopically enriched. In fact, the opposite is generally true: water vapor originating from low-latitude marine sources has a relatively enriched initial isotopic composition, whereas water vapor recycled through inland evapotranspiration is typically more depleted. During long-range transport, marine-sourced water vapor undergoes progressive isotopic depletion due to continuous rainout along the pathway, forming a systematic isotopic gradient from source to sink. Our analysis leverages this gradient to identify active transport corridors and partition the contributions of marine versus continental moisture sources. Our analysis shows that source-region ocean vapor isotopes show clear seasonality, and the modest isotopic depletion during extremes is also influenced by enhanced rainout modulated by along-path water vapor budget changes. This decomposition cannot be achieved with trajectory analysis alone.

We fully agree that “just checking $\delta^{18}\text{O}_p$ variations” is not sufficient justification. In the revised manuscript, we will restructure the isotopic analysis around these two explicit scientific objectives.

It is not clear which IsoGSM simulation was used by the authors. Are the outputs from the simulation from Bong et al. (2024), nudged to the u and v components of ERA5 winds at T62L28 spatial resolution? Or are they from another dataset? The reference <https://datadryad.org/stash/dataset/doi:10.6078/D1MM6B> is clearly not appropriate because it corresponds to monthly mean outputs until the year 2017! Such dataset needs to be cited appropriately

and, if necessary (i.e., for temporary dataset), an agreement for the use of these data needs to be asked to the authors. Moreover, there is no information about how the modeled values have been extracted from the dataset (e.g., nearest grid point from the locations, spatial resolution...).

Response: Thank you for raising this important question regarding the isoGSM dataset specification, citation, and processing procedures. We sincerely apologize for the ambiguity and incorrect reference in the original manuscript, which has caused unnecessary confusion. We have clarified all relevant details as follows, and all corresponding revisions will be incorporated into the revised manuscript.

(1) For the isoGSM version, methodological basis, and data source: The isotope simulation data used in this study are derived from the third generation of the Isotope-incorporated Global Spectral Model (isoGSM3, low-resolution version), the new generation of the isoGSM model family. The core theoretical framework of isotope cycling and fractionation parameterization was originally established by Yoshimura et al. (2008), and the updated model configuration and systematic intercomparison evaluation are fully documented in Bong et al. (2024). The full isoGSM3 dataset is publicly hosted on Zenodo (<https://zenodo.org/records/14681370>). The dataset provides 6-hourly outputs of water stable isotopes in both precipitation and atmospheric water vapor, which fully covers the temporal scope of our extreme event analysis.

(2) Correction of the original Dryad reference: The Dryad link (<https://datadryad.org/stash/dataset/doi:10.6078/D1MM6B>) cited in the original manuscript was a reference error. That dataset corresponds to an older generation (isoGSM2) of monthly mean outputs, which only covers up to 2017 and was used in our previous published ACP paper. It does not apply to the present synoptic extreme event analysis in this manuscript. We have removed this incorrect citation from the revised manuscript and replaced it with the correct Zenodo link for the isoGSM3 dataset, alongside the two primary methodological references (Yoshimura et al., 2008; Bong et al., 2024).

(3) Data extraction procedure: Modeled values were extracted using the nearest grid point method for the QXY precipitation sampling station (28.20° N, 113.01° E). The Mapoling (MPL) sounding station (28.12° N, 113.05° E) falls within the same isoGSM3 grid cell. We extracted 6-hourly $\delta^{18}\text{O}$ and $\delta^2\text{H}$ in precipitation ($\delta^{18}\text{O}_p$, $\delta^2\text{H}_p$) and vertically integrated atmospheric water vapor ($\delta^{18}\text{O}_v$, $\delta^2\text{H}_v$) for all event-scale analyses. All the above information will be added to Section 2.2 (Data Sources) of the revised manuscript to ensure full transparency and analytical reproducibility.

The comparison of the observations to IsoGSM and ERA5 is also misleading. If one wants to explain the observed $\delta^{18}\text{O}_p$ values with IsoGSM $\delta^{18}\text{O}_p$ modeled values, one has to use also the modeled precipitation and temperature from IsoGSM, and not the ERA5 reanalyses. Please note the precipitation can be quite different between ERA5 and IsoGSM. Also, precipitation amount from

ERA5 is mainly from models, contrary to the temperature. Moreover, extreme precipitation value for the July 2017 event is probably not modeled in IsoGSM as well, which has a clear impact on modeled $\delta^{18}\text{O}_p$ (so the analyses based on modeled values is biased).

Response: Thank you for pointing out this important ambiguity regarding dataset usage. We apologize for the confusing descriptions in the original manuscript. This confusion originated from a very early conference discussion between the corresponding author and Prof. Kei Yoshimura: we correctly learned that isoGSM applies ERA5 for the model-driven inputs, but we mistakenly mixed up ERA5 driving inputs and isoGSM simulated output variables, leading to incorrect text stating that precipitation variables came from ERA5. This was a descriptive mistake rather than an error in our actual calculations.

In our practical analysis, precipitation-isotope, water-vapor-isotope, precipitation amount, and vertically-integrated water vapor flux Q are all derived from isoGSM outputs. ERA5 is used to plot 500 hPa geopotential height (H_{500}) for synoptic background maps; ERA5 precipitation and temperature products are never used for isotope interpretation or moisture-budget analysis. Thus, observed $\delta^{18}\text{O}_p$ is consistently compared against isoGSM-simulated precipitation, temperature, and isotope outputs, consistent with the principle you suggested.

We understand your concerns about the underestimation of precipitation amount in isoGSM and the absolute magnitude of local extreme precipitation such as the 2017 heavy rainfall event, which may potentially bias simulated $\delta^{18}\text{O}_p$. To quantify this effect, we have added event-specific model validation in Supplementary Table, reporting correlation and mean bias between station observations and isoGSM outputs for both extreme events. The validation demonstrates that, despite an underestimation or overestimation of the absolute rainfall magnitude at the storm's intensity, the day-to-day variability of daily precipitation from isoGSM compares favorably against station observations. The simulated event-scale $\delta^{18}\text{O}_p$ variations and isotopic anomalies are also well reproduced. On isoGSM precipitation bias and isotopic reliability, it is correct that isoGSM underestimates the magnitude of extreme precipitation, which is a well-documented limitation of coarse-resolution global isotope GCMs. However, our core isotopic conclusions do not depend on accurate simulation of extreme rainfall amounts: (1) Our primary isotopic findings concern spatial patterns (e.g., latitudinal gradients, continental effects) and along-path gradients (relative depletion from source to basin), not absolute isotopic values at exact precipitation intensities; (2) The observational isotope record at Changsha station confirms that the direction and magnitude of event-scale isotopic shifts are well captured by the model, even when precipitation amount is underestimated; (3) The key finding that extreme events only modestly perturb isotopic baselines is supported by both model and observations. In the revised manuscript, Section 2.2 will be fully rewritten to clearly distinguish isoGSM output variables and

ERA5-only plotting variables. We will also add discussion on the precipitation-magnitude limitation together with the event-scale validation results in Section 4. Should we receive the chance to submit a revised manuscript, all these revisions will be completed.

It is also not clear how the HYSPLIT model has been run. No experimental setup is described. Which input data have used? From which dataset (ERA5? Other?)?

Response: We apologize for the incomplete description of the HYSPLIT experimental setup. In the revised manuscript, we will add complete simulation details to Section 2.3 as follows:

For HYSPLIT configuration: (1) Model version: HYSPLIT v4.9 (Hybrid Single-Particle Lagrangian Integrated Trajectory model), developed by NOAA Air Resources Laboratory; (2) Input meteorological dataset: NCEP/NCAR Global Data Assimilation System (GDAS) reanalysis data, with a horizontal resolution of $2.5^{\circ} \times 2.5^{\circ}$, 6-hour temporal resolution, and 23 vertical pressure levels from 1000 hPa to 10 hPa; (3) Simulation mode: 5-day (120-hour) backward trajectory calculation.

The Endpoint locations were Mapoling station (MPL): 28.12° N, 113.05° E and Changde station (ChD): 29.03° N, 111.41° E. The endpoint heights were 1000 m, 3000 m, and 5500 m above ground level (AGL), selected to represent the lower, middle, and upper troposphere, corresponding approximately to the 900 hPa, 700 hPa, and 500 hPa pressure levels. The Endpoint time was 19:00 Beijing Time on January 28, 2008 (Event B) and June 25, 2017 (Event A), corresponding to the time of the radiosonde observations used for vertical structure analysis.

Rationale for 120-hour backward duration: Based on typical zonal wind speeds in mid-latitudes, air parcels from low-latitude source regions (Bay of Bengal, western Pacific) take approximately 3–5 days to reach the Dongting Lake Basin. A 120-hour backward integration captures the full transport history from source to basin.

The term centennial is very misleading because it refers more to paleoclimates. Instead, use term such “once-in-a-century”.

Response: We fully agree with this suggestion and thank you for pointing out this terminology issue. In climatological and paleo-climatological research, “centennial” indeed typically refers to time scales of 100 years (e.g., centennial variability, centennial resolution), not to event return periods. In the revised manuscript, we will replace all instances of “centennial extreme events” and related expressions with “once-in-a-century extreme events” throughout the entire text, including the title, abstract, main text, figure captions, and conclusions. This will accurately describe the return period of the events while avoiding confusion with paleo-climatological temporal scale terminology.

Technical comments

References to the water isotopes are written from the fourth line of the introduction (lines 32-33), without introducing the concept of water isotopes and in what way they can be useful for the study.

Response: We agree that the concept of stable water isotopes should be explicitly introduced before its first application. In the revised manuscript, we will insert a clear conceptual definition at the first mention of water isotopes in the Introduction: Stable water isotopes ($\delta^{18}\text{O}$ and $\delta^2\text{H}$) are naturally occurring variants of water molecules that differ in mass due to heavy oxygen and hydrogen isotopes. During phase changes (evaporation, condensation) and atmospheric transport, mass-dependent fractionation processes modify isotopic ratios in predictable ways, creating characteristic “fingerprints” of water vapor sources, transport histories, and condensation conditions. These properties make water isotopes powerful tracers for diagnosing the origins and evolution of atmospheric water vapor. We will also briefly preview the specific roles isotopes play in this study, as outlined in our response to Specific Comment 2 above.

Lines 79-96: the quoted terms are misleading (stable water isotopes are not only chemical fingerprints) and simplification is needed.

Response: We acknowledge that describing isotopes solely as “chemical fingerprints” is an oversimplification. In the revised manuscript, we will revise this paragraph to use more precise and balanced language. Specifically, we will change the phrasing from “act as ‘chemical fingerprints’” to “are widely utilized as geochemical tracers, often referred to as ‘chemical fingerprints’ in the literature”, and we will streamline the description of each method to focus on its core function while avoiding overstatement. The integrated method framework will still be presented, but with clearer differentiation of their respective strengths and limitations.

Lines 102-103: just cite the paper.

Response: We will follow the comments, simplify this sentence, and retain only the necessary citation, removing redundant descriptive text as suggested.

Lines 191-192: this is wrong. IsoGSM was nudged to u and v components of winds, and sea surface boundary conditions (sea surface temperature, sea ice area fraction) were provided. Air temperature and water vapor fields are not driving factors, they are simulated.

Response: Thank you for correcting this inaccuracy. This was an error in our description of the model forcing. In the revised manuscript, we will correct this sentence to read: The current version of isoGSM is nudged to horizontal wind fields (u , v) to constrain large-scale circulation. Lower boundary

conditions are prescribed from observed sea surface temperature and sea ice concentration. Air temperature, specific humidity, and water isotope fields are prognostically simulated within the model.

Line 205: the reference to ERA-interim is not necessary.

Response: We will follow the comments and remove the unnecessary reference to ERA-Interim from the ERA5 description.

Line 207: the proper reference for ERA5 are Hersbach et al. (2020, <https://doi.org/10.1002/qj.3803>) and Soci et al. (2024, <https://doi.org/10.1002/qj.4803>).

Response: We will follow the comments and update the ERA5 citations to include the standard official references.

Lines 239-245: it's a bit strange to talk about the extreme events before introducing them. They should be properly introduced in the data section.

Response: We agree that introducing specific extreme events in the methodology section is premature. In the revised manuscript, we will restructure the text: (1) The methodology section (Section 2) will describe only general methods, datasets, and study site; (2) Detailed introduction of the two extreme events (temporal scope, intensity metrics, impacts) will be moved to the beginning of Sections 3.2 and 3.3, immediately before their respective analyses; (3) A brief overview of the two events will be retained in the Introduction to establish study motivation, but without going into detailed metrics.

Figure 2: the comparison should be made with IsoGSM outputs. Highlight the 2 events and make some air between the curves. Why there is missing data in panel b? ERA5 and IsoGSM outputs are available for this time period.

Response: We will implement the following revisions to Figure 2 if we are allowed to submit a revised manuscript: (1) Clarify data sources in the figure caption: All model time series used for model–observation comparisons, including isotopic variables ($\delta^{18}\text{O}_p$) and meteorological variables (precipitation P and air temperature T), will be sourced from the isoGSM, ensuring consistency across the whole panel. (2) Highlight the target extreme events and improve visual layout: We will add semi-transparent vertical shaded bands to denote the June 2017 rainstorm and January 2008 freezing event, so these key periods can be easily identified. We will also adjust the plotting settings to add visual separation between different curves and enhance readability. (3) Address the data gap in panel b: The missing values seen in the original Fig. 2b were caused by a data extraction error during plotting, rather than inherent gaps in the original isoGSM dataset. We have re-extracted and reprocessed the complete

time series and will fill this artificial gap in the revised figure.

Line 296: The extreme rainstorm event occurring from June 22 to July 2, 2017 (referred hereafter as Event A).

Response: We will standardize event naming throughout the manuscript: (1) The full multi-day process (June 22–July 2, 2017) will be referred to as the “June 2017 once-in-a-century extreme rainstorm event”; (2) The peak 4-day period (June 22–25) used for detailed process analysis will be designated “Event A”. The same naming convention will be applied consistently to the January 2008 freezing event.

Line 307-309: remove this sentence.

Response: We will follow the comment and remove the redundant sentence as suggested.

Figure 3: no unit for the precipitation, make the maps in colors.

Response: In the revised figure, we will add explicit precipitation units (mm) to the color bar and contour labels and convert the grayscale contour plots to color-filled maps with a clear color ramp for precipitation amount.

Lines 326-328: precipitation in ERA5 and IsoGSM are not the same. If one wants to explain the $\delta^{18}\text{O}$ signal, you have to use only IsoGSM outputs.

Response: We appreciate this important comment and fully agree that $\delta^{18}\text{O}$ signal interpretation must be based solely on isoGSM outputs. The confusing statements in original Lines 326-328 stemmed from our earlier textual misstatement; that is, we mixed the ERA5 driving inputs of isoGSM with isoGSM's own simulated diagnostics. In practice, all isotope mechanistic analyses of $\delta^{18}\text{O}_p$ and $\delta^{18}\text{O}_v$ use only isoGSM-simulated precipitation, temperature, water-vapor isotopes, and water vapor flux Q . ERA5 is used to plot 500 hPa geopotential height (i.e., H_{500}) for synoptic background visualization and is never used for isotopic diagnosis. We will remove and revise the ambiguous text at original Lines 326-328 in the revised manuscript. Meanwhile, Section 2.2 will be updated to explicitly distinguish isoGSM analysis variables and ERA5 plotting-only variables to avoid similar misreading. If we are allowed to submit a revised manuscript, these changes will be implemented.

Figures 4 and 6: use IsoGSM outputs. The figures are not readable, the red squares are not visible, no units, water vapor transport pathways are not explained or described (how you got them?). No comparison to the climatological mean.

Response: We will comprehensively improve Figures 4 and 6 as follows: (1) Improve readability: Increase figure resolution, adjust color scales for better contrast, increase font sizes for labels and color bars, and add units to all color bars; (2) Red box labels: Enhance the visibility of the red rectangular boxes and add an explicit note in each caption confirming that they delineate the Dongting Lake Basin; (3) Pathway identification criteria: Add a detailed description of the objective pathway identification method in Section 2.3, including the three criteria: continuous high-flux band, consistent directionality, and flux magnitude exceeding adjacent regions. We will also cite our previous study (Xiao et al., 2025a) where this method was established and validated. (4) About the Climatological comparison: We will construct climatological-mean reference fields corresponding to the exact calendar windows of the two extreme events: the 4 days of June 22–25 for the 2017 rainstorm event, and January 25–28 for the 2008 freezing disaster. These climatological composites are calculated from multi-year isoGSM outputs for the same 4-day time windows.

The full climatological mean spatial maps will be placed in the Supplementary Material. In the main text (Sections 3.2 and 3.3), we will explicitly refer to these supplementary climatology figures and conduct quantitative and qualitative comparisons between the extreme-event fields (main-text Figures 4 and 6) and the synchronous climatological background. This design keeps the main-text figures focused on the two target extreme events while providing complete climatological context for readers. Should we be granted the opportunity to submit the revised manuscript, the supplementary climatology figures, cross-references in the main text, and corresponding comparative discussions will all be implemented.

Lines 392-393: not clear, please rephrase.

Response: We will rephrase this sentence for greater clarity: The low $\delta^{18}\text{O}_v$ values observed along the pathway are associated with persistent low-level convergence and continuous heavy rainfall. The intense, sustained rainout preferentially removes heavy isotopes from the atmospheric water vapor column, resulting in a strongly depleted vapor isotopic composition.

Figure 5 and 7: there is no clear explanation about the numbers in the x-axis. A reader cannot locate the serial number 15 on a map.

Response: We will improve the explanation of the x-axis in three ways: (1) Expand the figure captions to clearly state that the numbers on the x-axis represent sequentially numbered grid points along the transport pathway, ordered from the source region (point 1) to the Dongting Lake Basin (final point); (2) Add a supplementary table (Table S1) listing the geographic coordinates (latitude, longitude) of each numbered point along all pathways.

Figure 8: legend is missing. Equations for the 3 colors should be shown and statistical significance of the difference between the equation should be made. To say just blue is a bit above and red a bit below the LMWL is not enough.

Response: We will significantly enhance Figure 8 and its analysis: (1) Add a complete legend: Clearly label all point categories (all samples, June 2017 event, January 2008 event) and the LMWL fit line. (2) Add regression equations: Present the linear regression equations (slope, intercept) and R^2 values for all three groups directly on the figure; (3) Statistical significance testing: Perform analysis of covariance (ANCOVA) to test whether the slopes and intercepts of the event-specific regression lines differ significantly from the overall LMWL. The p -values for these tests will be reported in the figure caption.

Figure 9: again, no comparison to the mean state.

Response: Thank you for this valuable suggestion regarding vertical profile comparisons. We acknowledge the absence of climatological mean sounding comparisons in Fig. 9. The vertical profiles shown in this figure are constructed from real-time radar and sounding observations, with the primary goal of diagnosing atmospheric stability, characterizing stratification features, and identifying the positions of frontal zones and upper-level synoptic systems. Vertical profiles vary substantially across different weather systems and may also differ notably at different locations or time stages within the same synoptic event, even for events of the same type. For instance, extreme precipitation events can be driven by fronts, cyclones, or typhoons, each associated with distinct vertical structures. Given such inherent variability, defining a representative mean vertical profile for a given precipitation event is not straightforward in synoptic analysis.

It is important to clarify that the primary purpose of presenting the sounding data in Fig. 9 is not to quantify climatological anomalies of vertical meteorological variables, but to diagnose the fine vertical structure of the frontal system during the mature phase of each extreme event. Specifically, these profiles are used to identify the height of the frontal inversion layer, characterize the vertical shear of wind direction and speed, and describe the vertical distribution of temperature and specific humidity across the frontal zone. These structural features in turn explain the differences in water vapor transport characteristics at different altitudes, which is a core focus of our vertical transport analysis in Section 4.3. For example, the observed wind direction rotation with height directly confirms the frontal zone position (~ 800 hPa for the 2008 freezing event, ~ 650 hPa for the 2017 rainstorm event), and supports our interpretation of why vertically integrated water vapor flux directions can differ from wind directions at individual heights within intense frontal systems.

While a comparison against multi-year mean vertical profiles would provide additional context for frontal structure, the core function of these sounding profiles is to characterize the internal vertical structure of the frontal systems during the events and support the analysis of height-dependent water vapor transport. Therefore, the lack of climatological mean comparison does not undermine the key conclusions of this study. In the revised manuscript, we will add a clear statement of this analytical purpose and data limitation in the figure caption and the corresponding results section.

Code/Data availability (line 705): see my comment about IsoGSM outputs.

Code/Data availability (lines 705-707): this is not acceptable. If the paper is accepted, the data should be stored in an open access repository such as Zenodo.

Response: Thank you for raising this critical point regarding data accessibility and transparency. We have revised our data availability statement comprehensively to address both the isoGSM dataset specification and the open deposition of observational data, in full alignment with ACP journal policy. Regarding the isoGSM outputs: We have clarified the dataset version, source, and citation in the revised manuscript. The 6-hourly isoGSM3 dataset used in this study is a publicly accessible resource hosted on Zenodo (<https://zenodo.org/records/14681370>). The core methodological framework and isotope fractionation parameterization of the model are fully documented in Yoshimura et al. (2008) and Bong et al. (2024), ensuring full methodological reproducibility.

Regarding the observational data: We fully agree with the requirement for open deposition of data supporting the paper's conclusions. In the revised manuscript, we will deposit all station-based observational data used in this study into the Zenodo open-access repository with a permanent DOI. This dataset includes: (1) daily meteorological records (precipitation amount, air temperature, wind speed, specific humidity) from all 97 meteorological stations across the Dongting Lake Basin during the two extreme event periods; (2) event-scale precipitation stable isotope data ($\delta^{18}\text{O}$, $\delta^2\text{H}$) and meteorological data from the Changsha stations; (3) the sounding data during the two extreme events. The full revised Data Availability section will clearly list the source, access link, and deposition plan for each dataset. Should we be granted the opportunity to submit a revised manuscript, this fully revised data availability statement will be included.