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Dear Editor Attila Demény,

With this cover letter, we are submitting the revised manuscript entitled, “**Seasonal patterns and diagnostic values of $\delta^2\text{H}$, $\delta^{18}\text{O}$, d-excess, and $\Delta^{17}\text{O}$ in precipitation over Seoul, South Korea (2016–2020)**”, for publication in *Earth System Science Data*. Based on the comments from the editor and the four reviewers, we have major changes of the manuscript, which are detailed below. Based on the comments from the editor and four reviewers, we have summarized the issues as following.

Reply to the comments by the reviewer 1

1. General Comments

I suggest Authors considering the following paper in the revision: Terzer-Wassmuth, S., Araguás-Araguás, L.J., Wassenaar, L.I. et al. Global and local meteoric water lines for $\delta^{17}\text{O}/\delta^{18}\text{O}$ and the spatiotemporal distribution of $\Delta^{17}\text{O}$ in Earth’s precipitation. Sci Rep 13, 19056 (2023). <https://doi.org/10.1038/s41598-023-45920-8>

This global review presents comparable data from Cheongju locating from ~100 km south from Seoul from a partially overlapping period (2015–2018) compared to the Seoul record. So comparing the main features must be included in this study. For instance, the $\delta^{17}\text{O}/\delta^{18}\text{O}$ regression reported for Cheongju ($\delta^{17}\text{O} = 0.5283 \times \delta^{18}\text{O} + 0.0216$) definitely can be compared to the equation derived from the Seoul dataset. In addition, the seasonal variation for the overlapping period should be compared in a plot to confirm the spatial consistency. This might bring some major change in section 4.2.

Response:

We thank the reviewer for this insightful suggestion and for drawing our attention to the comprehensive dataset presented by Terzer-Wassmuth et al. (2023). We fully agree that a comparison between the Seoul and Cheongju records will substantially enhance the regional context and strengthen the interpretation of our results.

Following this recommendation, we will include a new comparative analysis between our Seoul dataset (2016–2020) and the Cheongju precipitation record reported by Terzer-Wassmuth et al. (2015–2018). The overlapping period (2016–2018) will be used for a direct intercomparison of both sites.



Specifically, we will compare the $\delta^{17}\text{O}$ – $\delta^{18}\text{O}$ relationships derived from the two locations. The regression obtained from the Seoul dataset ($\delta^{17}\text{O} = 0.528 \times \delta^{18}\text{O} + 0.0105$) shows a slope that is nearly identical to that from Cheongju ($\delta^{17}\text{O} = 0.5283 \times \delta^{18}\text{O} + 0.0216$). This high degree of similarity indicates consistent mass-dependent fractionation across central Korea. The slightly lower intercept for Seoul will be interpreted as reflecting the stronger maritime influence and higher humidity compared with the inland Cheongju site.

Finally, we will revise Section 4.2 to discuss these results in the context of large-scale water vapor mixing and continental air-mass influence during winter, as well as to emphasize that the agreement between Seoul and Cheongju confirms that $\Delta^{17}\text{O}$ can serve as a robust diagnostic of regional hydroclimatic processes in East Asia. A brief mention of this regional consistency will also be added to the Summary section, and Terzer-Wassmuth et al. (2023) will be included in the reference list. We appreciate this valuable comment, which will significantly improve the completeness and regional relevance of our revised manuscript.

I missed very much a brief methodological description on the derivation of the local meteoric water line (LMWL). There are a set of methods which can be applied to approximate the linear covariance between $\delta^{18}\text{O}$ and $\delta^2\text{H}$ (see Crawford et al., 2014 <https://doi.org/10.1016/j.jhydrol.2014.10.033>). Ordinary least square (OLS) regression is more sensitive to the evaporatively enriched compositions typically accompanied with small precip amount, while reduced major axis (RMA) is theoretically more suited to development of a MWL than OLS because they consider errors in both $\delta^{18}\text{O}$ and $\delta^2\text{H}$. Precipitation-weighted least squared regression can be the most suitable to derive a LMWL for reference in isotope hydrological comparisons. So, it would be necessary to describe how the LMWL was calculated in this study.

Response:

We thank the reviewer for emphasizing the importance of clearly describing how the Local Meteoric Water Line (LMWL) was derived. In the revised manuscript, we will expand the methodological explanation to specify that the LMWL was calculated directly from the biweekly isotope dataset, which provides the highest temporal resolution of precipitation isotopic variability available for this site.

The regression was performed using an ordinary least squares (OLS) approach applied to the $\delta^2\text{H}$ and $\delta^{18}\text{O}$ values of all 130 individual samples collected between 2016 and 2020. Because the analytical precision for both isotopes is very high ($\pm 0.10\text{‰}$ for $\delta^2\text{H}$ and $\pm 0.07\text{‰}$ for $\delta^{18}\text{O}$), the OLS method is appropriate for deriving the LMWL, as recommended by Crawford et al. (2014) and other isotope-hydrology studies.

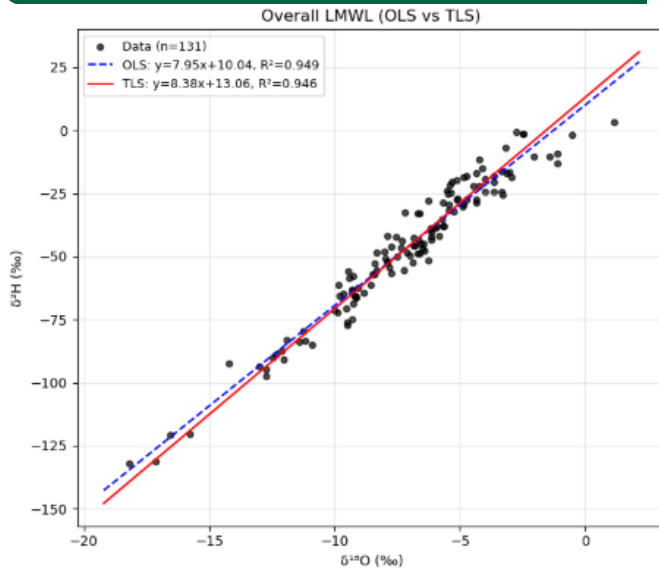
Nevertheless, we will also include a comparison with a total least-squares (TLS) regression to test the sensitivity of the LMWL parameters to possible errors in both variables. The resulting equations from OLS ($\delta^2\text{H} = 7.79 \times \delta^{18}\text{O} + 10.24$, $R^2 = 0.92$) and TLS ($\delta^2\text{H} = 8.44 \times \delta^{18}\text{O} + 14.8$, $R^2 = 0.917$) are nearly identical within 1σ uncertainty,



consistent with findings from Lee et al. (2022) that OLS and TLS solutions converge when analytical errors are small.

This methodological clarification will make explicit that the LMWL was derived from high-temporal-resolution (biweekly) precipitation data rather than aggregated monthly means, ensuring that the regression reflects the full variability of the observed isotopic composition.

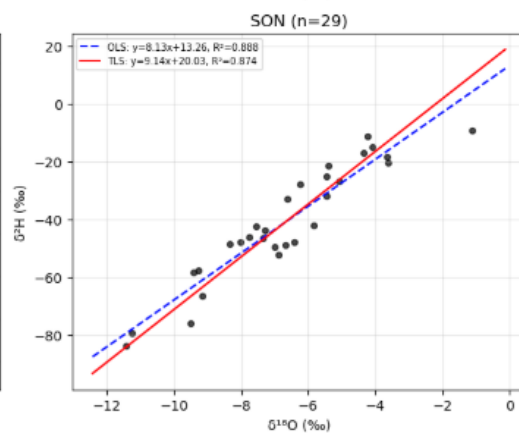
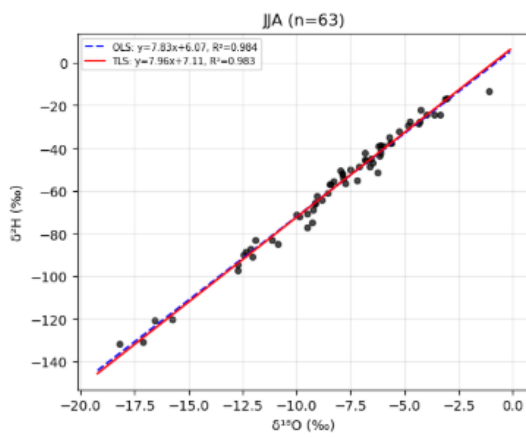
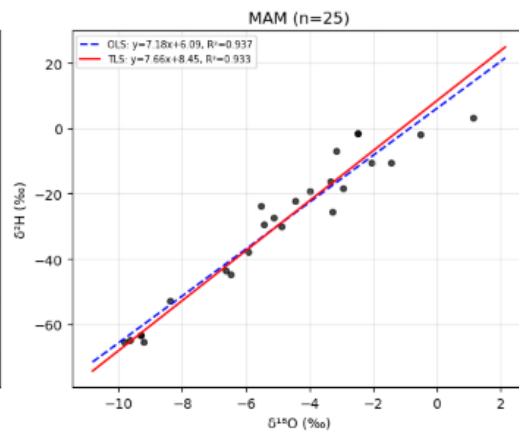
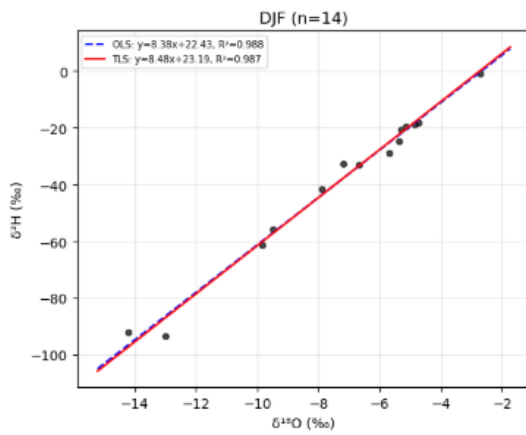
We will add a short paragraph in the Methods section describing the calculation workflow and include a figure in the Supplement (Fig. Sx) showing the OLS and TLS regression lines for the overall dataset and for seasonal subsets. These additions will improve the reproducibility of the analysis, clarify the regression method used, and justify the use of the biweekly dataset as the basis for calculating the LMWL.



=== Overall ===

OLS: slope=7.953, intercept=10.044, $R^2=0.949$

TLS: slope=8.377, intercept=13.065, $R^2=0.946$





2. Specific Comments

line 13: I suggest rephrasing in this way “The oxygen isotope composition ($\delta^{18}\text{O}$) ranged widely from 1.15 to -18.21‰ , hydrogen isotope composition ($\delta^2\text{H}$) varied from...”

Response:

We thank the reviewer for the helpful suggestion to improve the phrasing for isotope notation consistency. In the revised manuscript, the sentence in line 13 will be reworded exactly as suggested to read:

“The oxygen isotope composition ($\delta^{18}\text{O}$) ranged widely from 1.15 to -18.21‰ , hydrogen isotope composition ($\delta^2\text{H}$) varied from 3.3 to -132.0‰ , and the ^{17}O -excess ($\Delta^{17}\text{O}$) ranged from 69 to -28‰ .”

This phrasing is clearer and aligns with common terminology used in stable isotope literature.

lines 56-57: I suggest citing the study of Terzer-Wassmuth et al., 2023 mentioned in the general comment section.

Response:

We thank the reviewer for pointing this out and for recommending the inclusion of the recent study by Terzer-Wassmuth et al. (2023), which provides a comprehensive global assessment of $\delta^{17}\text{O}$ – $\delta^{18}\text{O}$ relationships and $\Delta^{17}\text{O}$ distributions in precipitation. In the revised manuscript, the suggested citation will be added at the end of the sentence in lines 56–57, so that it now reads:

“Meanwhile, $\Delta^{17}\text{O}$ — defined as the logarithmic deviation from the global meteoric water line between $\delta^{17}\text{O}$ and $\delta^{18}\text{O}$ — responds to non-equilibrium processes such as vapor mixing and supersaturated condensation and provides unique information about the dynamical history of atmospheric moisture (Barkan and Luz, 2007; Benetti et al., 2014; Landais et al., 2008; Terzer-Wassmuth et al., 2023).”

This new citation highlights the most recent global analysis of $\Delta^{17}\text{O}$ in precipitation and strengthens the discussion of triple-oxygen-isotope systematics within a broader spatial context.

line 104: Have you applied oil to prevent evaporation? If not please report it in the appropriate paragraph describing methodology, if yes, please report if you experienced any complication during analysis.

Response:

We appreciate the reviewer’s careful attention to the sample handling procedure and the question regarding the use of mineral oil to prevent evaporation during precipitation collection.



In this study, no oil was applied to the precipitation collector, and this choice was intentional. The isotopic analyses were performed using a wavelength-scanned cavity ring-down spectrometer (WS-CRDS; Picarro L2140-i), which is highly sensitive to organic contamination.

Several previous studies have shown that the use of oil layers for evaporation control can introduce organic compounds into water samples and lead to spectral interference and measurement bias in CRDS-based isotope analysis systems (e.g., elevated baseline noise and abnormal $\delta^2\text{H}$ signals). To avoid such analytical complications, we deliberately did not use any mineral or paraffin oil. Instead, the sampling system was specifically designed to minimize post-collection evaporation mechanically rather than chemically. Precipitation was collected through a funnel system installed on an open rooftop (Fig. 1C in the manuscript). The funnel was connected directly to pre-cleaned, airtight PTFE bottles via narrow tubing, ensuring that samples were isolated from external airflow and direct sunlight immediately after rainfall. This configuration effectively prevented evaporation during and after collection. Accordingly, the following clarification will be added to the Methods section (around line 104) in the revised manuscript:

“No mineral oil was applied to prevent evaporation during precipitation collection, because the presence of organic compounds can interfere with spectroscopic isotope analysis in cavity ring-down systems. Previous studies have demonstrated that even trace amounts of organic contamination, such as mineral oil residues, can cause spectral interference and bias $\delta^2\text{H}$ and $\delta^{18}\text{O}$ measurements obtained by WS-CRDS (Gupta et al., 2009). Instead of using oil, we employed a funnel system that physically minimized post-collection evaporation. Precipitation was funneled directly into pre-cleaned and sealed PTFE bottles immediately after sampling period (~2week), thereby minimizing exposure to air and sunlight.”

We thank the reviewer for this valuable comment, which helped us to provide a more complete and transparent description of our sampling methodology.

lines 106-107: To verify the evaporation proof storage in HDPE bottle Authors might consider citing the following study: Spangenberg, J.E. (2012). Caution on the storage of waters and aqueous solutions in plastic containers for hydrogen and oxygen stable isotope analysis. – Rapid Communications in Mass Spectrometry, 26, 2627–2636.

Response:

We thank the reviewer for highlighting this important aspect of sample storage and for recommending the reference of Spangenberg (2012). The study indeed demonstrated that long-term storage of water samples in HDPE containers at room temperature may lead to isotopic drift caused by molecular diffusion and potential H–O exchange across the polymer matrix. We appreciate the reviewer’s attention to this issue and have expanded the description of our storage protocol accordingly.

In our study, several precautions were implemented to ensure isotopic stability during storage. All samples were transferred immediately after collection into pre-



cleaned HDPE bottles with PTFE-lined caps, sealed with Parafilm®, and stored continuously at -20°C from the time of collection until analysis. The combination of a PTFE barrier, Parafilm sealing, and frozen conditions effectively eliminates the processes identified by Spangenberg (2012), since both molecular diffusion and polymer–water exchange are suppressed at subzero temperatures.

Furthermore, we have empirically verified the isotopic stability of our storage protocol by repeated analysis of our in-house standard (STYX), which was stored under the same conditions as the precipitation samples. Over several years, the results show no measurable drift in $\delta^2\text{H}$, $\delta^{18}\text{O}$, or $\Delta^{17}\text{O}$, demonstrating the reliability of our frozen HDPE storage method. We will also include this information in the revised Methods section to make explicit that isotopic reproducibility under our storage regime was carefully monitored.

lines 120-123: I'm confused. I think that the long-term analytical precision should be estimated based on the repeated measurement results of your laboratory standards rather than based on the calibration standards. see e.g <https://doi.org/10.1002/rcm.5037> and <https://doi.org/10.1556/24.2023.00134>

Response:

We thank the reviewer for the valuable comment and for highlighting the need to clearly distinguish between calibration accuracy and long-term analytical precision. We appreciate the reviewer's insightful comment and would like to clarify how our in-house laboratory standards were used and how long-term analytical precision was determined. Two in-house laboratory standards, STYX and KT, were routinely used during isotope measurements.

STYX is natural water collected from the Styx Glacier region in Antarctica, and it has been used as a long-term reference standard to evaluate the stability of our WS-CRDS system (Picarro L2140-i) over several years. In contrast, KT is locally sourced tap water, whose isotopic composition is similar to that of the precipitation samples analyzed in this study. KT was primarily employed during each analytical run to mitigate potential memory effects that can arise when switching between isotopically distinct standards or samples.

Each analytical session began with international reference waters (VSMOW2, SLAP2, and GISP) for scale normalization. After calibration, sample analyses were performed, and every ten sample vials, the two in-house standards (STYX and KT) were measured. The repeated measurements of STYX provide the basis for estimating the long-term analytical reproducibility, while KT serves as an intermediate composition check to ensure measurement continuity and minimize carryover bias.

The long-term analytical precision, reported as $\pm 0.10\text{‰}$ for $\delta^2\text{H}$, $\pm 0.07\text{‰}$ for $\delta^{18}\text{O}$, and $\pm 0.01\text{‰}$ for $\delta^{17}\text{O}$, was derived from the 1σ standard deviation of repeated STYX measurements accumulated over several years. Both STYX and KT are calibrated against VSMOW2 and SLAP2 and are routinely used as working standards at the



Korea Polar Research Institute. To make this explicit, we will revise the Methods section (lines 120–123) as follows:

“At the beginning of each analytical session, international reference waters (VSMOW2, SLAP2, and GISP) were measured for VSMOW–SLAP scale normalization. Subsequently, samples were analyzed, and every ten samples, two in-house laboratory standards (STYX and KT), both calibrated against VSMOW2 and SLAP2, were analyzed to monitor instrumental performance. STYX, a natural water collected from the Styx Glacier region in Antarctica, was used to assess the long-term analytical reproducibility of the WS-CRDS, while KT, a locally sourced tap water with isotopic composition similar to the precipitation samples, was used to reduce potential memory effects during analysis. The long-term 1σ standard deviations obtained from repeated STYX measurements over several years were $\pm 0.10\text{‰}$ for $\delta^2\text{H}$, $\pm 0.07\text{‰}$ for $\delta^{18}\text{O}$, and $\pm 0.01\text{‰}$ for $\delta^{17}\text{O}$.”

This revision clarifies the specific roles of STYX and KT and demonstrates that our procedures followed established best practices for ensuring both analytical accuracy and stability over the multi-year measurement period.

line 133: Have you experienced a threshold regarding precipitation amount? I mean a minimum amount of precipitation below which the collected water was insufficient for the analysis. For instance, this study reported a ≥ 0.56 mm/day during the rainy season, and 0.5 mm/day during the snowy season: <https://doi.org/10.1038/s41597-022-01148-1>

Response:

We appreciate the reviewer’s insightful question regarding the minimum precipitation amount required for isotope analysis and for referring to the study of Freyberg et al. (2022), which quantified event-scale precipitation thresholds for automated daily collection systems.

In our study, precipitation was sampled on a biweekly cumulative basis, rather than at daily or event intervals. Each collector remained open for approximately 14 days, continuously accumulating all rainfall or snowfall events that occurred within that period. As a result, it was not possible to resolve the isotope composition of individual precipitation events or to determine the precise precipitation amount associated with each sample. The sampling strategy was designed to ensure sufficient volume for triple-isotope analysis while minimizing field visits and operational complexity over the five-year observation period.

Because each biweekly sample represents an integration of multiple precipitation events, the total collected water volume was consistently well above the analytical requirement for WS-CRDS measurements (> 3 mL per sample). Even during the driest winter months, the cumulative sample volumes exceeded 5–10 mL, which is far greater than the minimum volume typically needed for high-precision δ - and $\Delta^{17}\text{O}$ determinations. Consequently, no samples had to be excluded due to insufficient



volume, and no empirical lower-precipitation limit could be derived from this dataset.

We acknowledge that Freyberg et al. (2022) reported event-scale thresholds of approximately 0.56 mm day^{-1} for rainfall and 0.5 mm day^{-1} for snowfall using high-frequency automated samplers. However, these thresholds are intended for studies seeking to resolve isotopic variability at individual-event or daily scales. Because our approach integrates over two-week intervals, the cumulative precipitation amounts in our samples were one to two orders of magnitude larger than those minimum thresholds, and thus such event-based criteria are not directly applicable to our dataset.

To clarify this in the revised manuscript, we will add a short paragraph in the Methods section stating that the sampling followed a biweekly cumulative protocol without a defined precipitation threshold, that all collected volumes were sufficient for analysis, and that no volume-related bias or missing data resulted from small-precipitation events. This additional explanation will make explicit that our dataset covers the full range of seasonal precipitation—including very low-intensity winter conditions—without losses due to volume limitations, ensuring the completeness and reliability of the isotopic record over the five-year period.

lines 136-137: The sentence sounds like figure caption. I suggest omitting this sentence and referring to Fig 3 at the end of the next sentence (in line 139)

Response:

We thank the reviewer for this careful and helpful stylistic suggestion. We fully agree that the sentence in lines 136–137 —

“Figure 3 presents monthly box plots for these parameters with a sine-function fit.” — reads more like a figure caption than a part of the main text and therefore interrupts the narrative flow of the Results section.

In the revised manuscript, we have deleted this sentence and integrated the reference to Figure 3 at the end of the subsequent sentence (line 139) to improve readability and cohesion. This change allows the description of the isotopic variability to flow naturally without an abrupt figure-statement transition while still directing the reader to the relevant figure for visual reference. The revised paragraph will read as follows:

“A total of 130 precipitation samples were collected during the study period. The measured isotopic compositions of precipitation varied considerably: $\delta^{17}\text{O}$ ranged from 0.61 to -9.62‰ (average: -3.75‰); $\delta^{18}\text{O}$ from 1.15 to -18.21‰ (average: -7.11‰); and $\delta^2\text{H}$ from 3.3 to -132.0‰ (average: -46.6‰). The d-excess fluctuated between 24.9 and -5.9‰ (average: 10.4‰), whereas ^{17}O -excess ranged from 69 to -28‰ (average: 16.8‰). For all three isotopic parameters ($\delta^{17}\text{O}$, $\delta^{18}\text{O}$, and $\delta^2\text{H}$), the precipitation was relatively depleted during the coldest months (December to February), became progressively enriched through March and April as temperatures



increased, and then sharply depleted again between June and August when precipitation peaked (Fig. 3)."

This revision follows the reviewer's recommendation precisely: the sentence resembling a figure caption was removed, and the figure citation was relocated to the end of the descriptive sentence where it logically supports the discussion of seasonal isotopic variability. We believe this edit significantly improves the clarity, coherence, and overall readability of the paragraph.

line 159: I suggest writing „The linear relationship...” instead of „The relationship...” at the beginning of this sentence.

Response:

We thank the reviewer for this precise and helpful editorial suggestion. We agree that the expression “The linear relationship ...” is clearer and more technically appropriate in this context, as the discussion in this section explicitly refers to the $\delta^2\text{H}$ – $\delta^{18}\text{O}$ regression used to define the Local Meteoric Water Line (LMWL).

In the revised manuscript, we will change the sentence accordingly. The phrase at the beginning of line 159, previously written as “The relationship between the precipitation $\delta^{18}\text{O}$ and $\delta^2\text{H}$...” has been changed to “The linear relationship between the precipitation $\delta^{18}\text{O}$ and $\delta^2\text{H}$...” to emphasize that the relationship being described is specifically a linear regression relationship. This modification will improve technical precision and stylistic clarity while fully aligning with the reviewer's recommendation.

lines 161 & 185: I think that double brackets are not needed when referring to panels of certain figures.

Response:

We thank the reviewer for pointing out this typographical issue and for noting the unnecessary use of double brackets when referring to figure panels. We agree that only single parentheses should be used when citing individual panels in figures, following the journal's style conventions. In the revised manuscript, we will remove the double brackets in the figure references mentioned in lines 161 and 185. Specifically, references currently written as “((A))” and “((B))” will be corrected to “(A)” and “(B)”, respectively.

This change will ensure consistency with ESSD formatting guidelines and standard scientific style for figure references (e.g., “Fig. 4 (a) and (b)” instead of “Fig. 4 ((A)) and ((B))”). We appreciate the reviewer's careful attention to detail, which will help improve the clarity and typographical consistency of the manuscript.

line 206: I think that “lower humidity” instead of “humidity”

Response:



We thank the reviewer for the helpful linguistic and scientific clarification. We agree that the phrase should explicitly refer to “lower humidity” rather than the general term “humidity,” because the discussion in this section describes conditions under which isotopic depletion occurs due to enhanced kinetic fractionation under drier air masses.

In the revised manuscript, we will change the phrase in line 240 from “... while locally, higher temperatures and humidity may promote ...” to “... while locally, higher temperatures and lower humidity may promote ...” to emphasize that the isotopic signal is associated with reduced ambient humidity typical of continental winter conditions. This revision will improve both the physical accuracy and the clarity of the description, aligning the text with the meteorological interpretation intended for this paragraph.

lines 209&213: I suggest writing “ $\delta^{18}\text{O}$ values” instead of simply the delta notation

Response:

We thank the reviewer for the helpful stylistic suggestion. We agree that using the full expression “ $\delta^{18}\text{O}$ values” rather than only the delta notation will make the text clearer and more precise, especially for readers less familiar with isotope notation. In the revised manuscript, we will replace the shorthand “ $\delta^{18}\text{O}$ ” with “ $\delta^{18}\text{O}$ values” in the two instances noted by the reviewer (lines 243 and 247).

The corresponding phrases will therefore read, for example, “... between $\delta^{18}\text{O}$ values and both temperature and precipitation ...” and “... $\delta^{18}\text{O}$ values was significantly ...” instead of simply “ $\delta^{18}\text{O}$.” This minor edit will improve consistency, readability, and technical clarity throughout the Results section, while preserving the scientific meaning of the original statements.

lines 225-235: Please add relevant citations in this paragraph.

Response:

We thank the reviewer for this valuable suggestion. We agree that adding relevant references will strengthen the discussion of the meteorological controls on the seasonal isotopic variability of precipitation over Korea.

In the revised manuscript, we will incorporate additional citations that address the temperature and amount effects on precipitation isotopes (Dansgaard, 1964), the climatology and variability of the East Asian monsoon (Ha et al., 2012; Huang et al., 2007), and regional isotope–meteorology relationships in Korea (Lee et al., 2015; Kim et al., 2019; Gautam et al., 2017). We will also reference Merlivat and Jouzel (1979) to support the interpretation of d-excess behavior under different humidity regimes. Specifically, the paragraph in lines 225–235 will be revised as follows (added citations in italics):

“The results of this study indicate that seasonal variations in precipitation isotopes in Korea are closely linked to local meteorological factors such as temperature, relative



humidity, and precipitation amount (Dansgaard, 1964; Lee et al., 2015) and reflect distinct seasonal regimes shaped by synoptic-scale circulation patterns (Ha et al., 2012; Huang et al., 2007). In summer, isotopic depletion is primarily governed by the amount effect under the influence of the East Asian monsoon, which delivers warm, moisture-rich air masses (Kim et al., 2019). In autumn, isotopic variability is enhanced by episodic typhoons introducing isotopically light precipitation associated with convective activity, while winter precipitation is strongly depleted in heavy isotopes and enriched in d-excess due to cold, dry continental air masses advected by the East Asian winter monsoon (Merlivat and Jouzel, 1979; Gautam et al., 2017)."

These additions will provide proper scientific grounding and connect our findings with the broader literature on East Asian monsoon dynamics and isotope–meteorology relationships.

lines 269-271: This sounds like figure caption. I suggest removing this sentence and simply referring to Fig7 after the relevant statements.

Response:

We thank the reviewer for this valuable suggestion. We agree that adding relevant references will strengthen the discussion of the meteorological controls on the seasonal isotopic variability of precipitation over Korea.

In the revised manuscript, we will incorporate additional citations that address the temperature and amount effects on precipitation isotopes (Dansgaard, 1964), the climatology and variability of the East Asian monsoon (Ha et al., 2012; Huang et al., 2007), and regional isotope–meteorology relationships in Korea (Lee et al., 2015; Kim et al., 2019; Gautam et al., 2017). We will also reference Merlivat and Jouzel (1979) to support the interpretation of d-excess behavior under different humidity regimes. Specifically, the paragraph in lines 225–235 will be revised as follows

"The results of this study indicate that seasonal variations in precipitation isotopes in Korea are closely linked to local meteorological factors such as temperature, relative humidity, and precipitation amount (Dansgaard, 1964; Lee et al., 2013) and reflect distinct seasonal regimes shaped by synoptic-scale circulation patterns (Ha et al., 2012; Huang et al., 2007). The findings indicate that, in summer, isotopic depletion is primarily governed by the amount effect under the influence of the East Asian monsoon, which delivers warm, moisture-rich air masses and produces intense rainfall events (Lee et al., 2003; Yu et al., 2006). Spring exhibits more variable isotopic signals due to transitional moisture sources and fluctuating atmospheric conditions, which result in a combination of continental and maritime influences. In autumn, isotopic variability is often enhanced by episodic typhoons, which introduce large volumes of isotopically light precipitation associated with strong convective activity. In contrast, winter precipitation is strongly depleted in heavy isotopes and enriched in d-excess due to the presence of cold, dry continental air masses advected by the East Asian winter monsoon (Kim et al., 2019; Lee et al., 2003)."



These additions will provide proper scientific grounding and connect our findings with the broader literature on East Asian monsoon dynamics and isotope–meteorology relationships.

Thank you very much for your time, effort, and patience in handling our manuscript. We look forward to your favorable consideration and to the opportunity for publication in Earth System Science Data.

Sincerely,
Jeonghoon Lee