Dear Editor,

We sincerely appreciate the Editor for carefully re-examining our revised manuscript and for highlighting the remaining terminology issues. We apologize that some of the formulations addressed in response to Reviewer 4's comments were not sufficiently refined in the previous revision. Although we had attempted to incorporate the reviewer's suggestions, we recognize that several expressions were not modified with sufficient precision and could still cause ambiguity for readers.

Following the Editor's suggestions, we have carefully re-examined the manuscript and made further revisions to improve the clarity, accuracy, and consistency of the descriptions, including the relevant terminology and supporting references. We hope that these revisions have addressed the remaining concerns. Detailed responses to each of the Editor's comments are provided below.

Dear Authors,

Thank you for your revisions, particularly those addressing the robustness of the results through the uncertainty analysis. You have indeed improved the manuscript's methodological transparency, data precision, and conceptual clarity.

I have a few remaining comments, particularly concerning the abstract and conclusions. I am somewhat disappointed to see that several formulations that were reportedly corrected in response to the reviewers' comments still appear in the manuscript, including the "inverse isotope–temperature relationship" in the abstract and the terminology contrasting "Rayleigh-dominated" and "kinetic fractionation." I therefore ask you to address the following comments carefully:

1. L. 12: What is meant by "Rayleigh-dominated long-range transport"? I consider long-range transport to be one process and cloud formation along the transport pathway to be another. Please reformulate this as "long-range transport with cloud formation underway." Otherwise, readers without a specific background in water-isotope physics may not understand what is meant.

Thank you for your suggestions. In the revised manuscript, we have replaced "Rayleigh-dominated long-range transport" with "long-range transport with cloud formation underway". Please see lines 12-13 for details.

2. L. 14: Please use a more appropriate term than "inverse isotope–temperature relationship" (Reviewer 4, Comment 10, Round 2).

Thank you for your suggestion. We have replaced "inverse isotope–temperature relationship" with "a negative $\delta^{18}O$–temperature relationship". Please see lines 14–15 for details.

3. L. 273: What is meant by “long-range Rayleigh distillation”? Again, this relates to the terminology issue raised by Reviewer 4.

Thank you for your suggestion. We agree that the original expression was not sufficiently clear. We have therefore replaced “long-range Rayleigh distillation” with “rainout during long-range transport” to provide a more accurate description. Please see line 273 for details.

4. L. 402: I think it is very important to mention here the key role of large-scale dynamical forcing and temperature advection (warm-air or cold-air advection, including subsidence-driven advection) in controlling surface latent heat fluxes, such as evaporation, sublimation, or vapour deposition, and thus the deuterium-excess signal in water vapour near the surface. This mechanism was discussed in detail by Aemisegger and Sjolte (2018) and investigated using ship-based observations from the Atlantic and the Southern Ocean by Thurnherr et al. (2021). These are key publications in this context.

A suitable location for adding this point may be around L. 423. Please add a statement along the following lines:

“…and has been explained mechanistically by the sign and magnitude of surface fluxes induced by large-scale advection of air masses (Aemisegger and Sjolte, 2018; Thurnherr et al., 2021).”

Aemisegger, F., and J. Sjolte, 2018: A Climatology of Strong Large-Scale Ocean Evaporation Events. Part II: Relevance for the Deuterium Excess Signature of the Evaporation Flux. Journal of Climate, 31, 7313–7336. https://doi.org/10.1175/JCLI-D-17-0592.1

Thurnherr, I., Hartmuth, K., Jansing, L., Gehring, J., Boettcher, M., Gorodetskaya, I., Werner, M., Wernli, H., and Aemisegger, F., 2021: The role of air–sea fluxes for the water vapour isotope signals in the cold and warm sectors of extratropical cyclones over the Southern Ocean. Weather and Climate Dynamics, 2, 331–357. https://doi.org/10.5194/wcd-2-331-2021

Thank you for this important suggestion. We have added a statement highlighting the role of large-scale dynamical forcing and air-mass advection in modulating surface fluxes and the resulting deuterium-excess variations, with the relevant references included. Please see lines 421–423 for details.

5. L. 430: The normalisation with respect to surface temperature is indeed essential for this type of investigation. Please refer here to Aemisegger and Sjolte (2018), who tested and discussed this aspect in detail in their global climatological study.

Thank you for this suggestion. We have added the reference to Aemisegger and Sjolte (2018) and highlighted the importance of normalisation with respect to surface temperature in this context. Please see line 429-433 for details.

6. L. 485: The statement that “advective Rayleigh distillation dominates” is again unclear in

terms of the underlying physical processes. Please reformulate it in physically explicit terms so that it is understandable to the general ACP readership.

Thank you for your suggestion. In the revised manuscript, we have rephrased this sentence to explicitly describe the underlying physical process as "Under extensive sea ice cover, the isotopic composition is primarily controlled by rainout during long-range moisture transport, resulting in a strong $\delta^{18}O$–temperature correlation and elevated d-excess in colder regions" Please see lines 487-489 for details.

7. L. 488: Please replace the term "anti-temperature effect" with a more physically appropriate and precise formulation (Reviewer 4, Comment 10, Round 2).

Thank you for your suggestion. We have rephrased this sentence as "This shift breaks down the canonical temperature effect, resulting in a negative $\delta^{18}O$–temperature relationship". Please see Line 491 for details.