Response to anonymous referee #1

We thank Reviewer 1 for their time and effort to provide detailed and constructive feedback on the manuscript, which has improved the quality of the study. We have addressed all comments below and propose to implement the changes in a revised version of the manuscript.

Black: reviewer comment
Blue: author's response
Green: revised text

The article presents a temporal series of the isotopic composition of water vapor during the austral summer 2023/2024 at Dome C, East Antarctica. The data have been obtained using two different laser spectrometers: a Picarro Cavity Ring-Down Spectrometer (CRDS) and an AP2E Optical-Feedback Cavity Enhanced Absorption Spectrometer (OF-CEAS). According to Lauwers et al. (2024), the low-humidity OF-CEAS analyzer, which was supposedly deployed in the field for this paper, should perform better than the CRDS at low humidity, but in this study it seems to give worse results.

A comparison between the measured and the LMDZ6-iso simulated isotopic composition of water vapor has also been carried out in this paper. The modeled and measured data show a good agreement for humidity and also show an overall agreement for δ^{18}O, δD and, to a certain extent, for deuterium excess, but LMDZ6-iso, while capturing the general variability, fails to obtain the correct isotopic values as well as the magnitude of the observed diurnal cycles.

Line 15 the measurement period is more than 3 months rather than 2.5 months

We refer here to the part of the measurement period that is available in public access in Landais et al. (2024b), which is 2.5 months (December 6th 2023 – February 14th 2024). However, it is correct that the whole measurement period is longer than that (3.5 months). We chose to show the whole measurement period in the manuscript but explain why we only focus / make available 2.5 months of the dataset in the Section 3.2 of the manuscript. We also have improved the text regarding this matter (see our answer to the Reviewer 2 comment n°40).

Line 46-47 change "such as encountered on the East Antarctic Plateau, is a technical challenge since most laser spectrometers are designed for measuring accurately within a range of humidities between 5,000 and 30,000 ppmv" with "such as those encountered on the East Antarctic Plateau, presents a technical challenge, as most laser spectrometers are designed for measuring accurately within a range of humidities between 5,000 and 30,000 ppmv"

Modified.

Line 57-58 how is the commercially available Picarro laser spectrometer adapted for low humidity measurements?

The phrasing of our original sentence might be confusing. The commercial Picarro analyser is not adapted to low humidity measurements but calibrated for low humidities. It is only the AP2E analyser that was specifically designed for low humidities. To make this point clearer, we modified the text as follows (l. 57-59):

> We installed a new laser spectrometer (ProCeas, AP2E Inc.) adapted for low humidity measurements (Lauwers et al., 2025) in parallel to a Picarro L2130-i laser spectrometer and together with a calibration unit designed to generate low humidity levels (Leroy-Dos Santos et al., 2021).

Line 63 same as line 15

See our answer to the reviewer's first comment.

Line 91-91 I think it would be better to specify the Picarro model (L2130-*i*? L2140-*i*?) instead of the identifier of your instrument. The same for the AP2E instrument: is it a ProCeas?

We use the identifier of our instruments to make the difference between the two different Picarro laser analysers that were installed at Concordia station (one of which the data is published in Leroy-Dos Santos et al., 2021). However we agree that the model of the analyser should be stated here. We modified the text as follows (l. 91-100):

> A Picarro L2130-i analyser (Picarro Inc., CRDS measurement technique, Picarro analyser hereinafter) was first installed in the summer season 2014-2015 for a test season and permanently in 2018 at Concordia station (referred to as Picarro HIDS2319 hereafter). [...] Due to instrumental issues, the Picarro HIDS2319 was replaced during the summer season 2021-2022 by a new Picarro L2130-i analyser (referred to as Picarro HIDS2308 hereafter). [...] In parallel to the Picarro analyser, a prototype of a AP2E ProCeas analyser (AP2E Inc., OF-CEAS measurement technique, AP2E analyser hereinafter), adapted for low humidity measurements (Lauwers et al., 2025), was installed during the summer season 2022-2023 and [...]. In this study we focus on the austral summer period 2023-2024 (December to mid-March), where both Picarro and AP2E analysers have been measuring in parallel on site.

Line 139 change "closest" with "close"

Modified.

Line 140 Is it possible for the deuterium excess to be +90‰ (based on a $\delta^{18}O$ =-80‰ and a δD =-550‰)?

The values for the atmospheric water vapour isotopic composition stated in this sentence correspond to published data from Leroy-Dos Santos et al. (2021). However, in their study they did not conclude on the atmospheric water vapour d-excess composition. In the new calibrated dataset presented in our study, we find a maximum d-excess of 93‰ ($\delta^{18}O$ = -77‰ and δD = -523‰) during the period from December to mid-February. To make clear that the values given here are already published data, we slightly modified the text as follows (l. 139-141):

The standard FP5 has an isotopic composition close to the atmospheric water vapour isotopic composition measured on site (varying between approximately -50‰ and -80‰ in δ^{18}O and between approximately -400‰ and -550‰ in δD during summertime, Leroy-Dos Santos et al., 2021) and it has been previously used to calibrate a Picarro [...].

Line 160-161 Although you give an explanation in line 180-183, I am still wondering why you used two laboratory standards mostly outside the range of the measured water vapor isotopic values. Couldn't you use, for example, the VSAEL standard with the FP5 standard?

We agree with the reviewer's comment on the fact that we used two standards mostly outside of the range of measured isotopic ratios. However, the standard mentioned here by the reviewer (VSAEL) was not yet made and available when the calibrations of the instruments were performed in the field. We therefore used the most depleted standard available to us at that time, which was the home-made FP5 standard.

Line 201-202 "i" is not subscript

Modified.

Line 273 What model is the Picarro HIDS2319?

Based on the reviewer's previous comment above, we added the information l. 91 about the model of the different Picarro analysers referred to in the text (they are all L2130-i analyzers).

Line 284-285 change "Below 500 ppmv, both δ^{18}O and δD show a divergence with decreasing humidity levels, in the opposite direction as for both Picarro analysers" with "Below 500 ppmv, both δ^{18}O and δD diverge as humidity levels decrease, but in the opposite direction observed in both Picarro analysers"

Modified.

Figure 4 $\delta^{18}O_{humcorr}$- $\delta^{18}O_{humcorr}$ [‰] and $\delta D_{humcorr}$- $\delta D_{humcorr}$ [‰] for the y axis is not very clear

We modified the vertical axes of Figure 4 to improve clarity. The axes are now: $\Delta\delta^{18}O_{humcorr}$ and $\Delta\delta D_{humcorr}$ (see our answer to Reviewer 2 comment n°34 for updated figure). We added the information of what it corresponds to in the figure caption as follows (l. 347-353):

Figure 4: Results of the regular [...]. Panels (b) and (c) show the measured isotopic ratios, corrected for the humidity-isotope response (Sect. 2.2.2 and 3.1.2), by both analysers during each calibration as a deviation of the mean over the whole period ($\Delta\delta^* = \delta^*_{humcorr} - \overline{\delta^*_{humcorr}}$, * is for any isotope). [...]

Line 374-375 and 381-382 what does it mean that "both analysers capture the linearity between the true δ^{18}O value of the two laboratory standards"? A line passing through two point is always a linear equation

We agree with the reviewer’s comment that these sentences are not very clear. Here we were highlighting that the slopes are close to 1, showing that the instruments don’t need a large correction to calibrate the data against VSMOW-SLAP (except for the biases shown by the intercepts). We modified the text to incorporate this comment as follows:

l. 373-375:

Both the Picarro and AP2E analysers have an absolute calibration slope for δ^{18}O close to one (respectively 0.98 and 0.97, Fig. 5a and Table 3). The intercepts of the linear relations [...].

l. 380-382:

For δD, the Picarro [...]. This indicates that the AP2E analyser requires a stronger correction to calibrate [...].

Figure 7 I can’t find “AP2E, raw” in panel a), which should be a blue dashed line; is it present in the graph? Was air temperature not available in the first and the last period of measurements? Where does the temperature come from? Is it AWS temperature or modeled temperature? You should specific it in the main text and in the figure caption

The “AP2E, raw” is present in the graph, superimposed by the “AP2E, calibrated” line, so not clearly visible. The temperature shown in red is the data from the 2-m level of a 42-m meteorological mast installed at Concordia station. However, as pointed out by the reviewer, there is some missing data at the beginning and end of the period and we do not explain where the data come from. We therefore used a different temperature dataset from the local AWS (Grigioni et al., 2022) to update the panel (a) of Figure 7. To accompany this change, we also modified the text and figure caption as follows:

l. 410:

[...] electric shutdowns. The air temperature shown in Fig. 7 is measured at 1.5 m above the surface by an Automatic Weather Station (AWS) installed in the vicinity of Concordia station (Grigioni et al., 2022).

l. 425:

In panel (a), the red line corresponds to the observed air temperature measured by the local AWS (Grigioni et al., 2022).

Line 455-456 there is a divergence between the two instruments between mid-February and mid-March. I know it’s due to the very low humidity which makes it hard for the laser spectrometers to correctly measure the isotopic composition, but how do you explain the different behavior of the Picarro and the AP2E laser spectrometers and which one is more reliable? I think this is an important point if you wish to measure the isotopic composition of water vapor in other seasons

We attribute the different behaviour of the two analysers to the humidity levels. At these low humidities (below 50 ppmv, which is most of the time in March when the two instruments show a very different behaviour), the humidity-isotope response calibrations are not constrained for either analyser (lowest calibration point is 50 ppmv, as explained in Sect. 2.2.2). Therefore neither instrument is really reliable at these humidities because the calibration is extrapolated. This is also the reason why we discard this period for the observation-model comparison. However, it seems that this particular Picarro analyser would be best in capturing the atmospheric water vapour isotopic composition at these low humidities, as shown in Figure 6b and c where the diurnal cycle in δ^{18}O and δD measured by the Picarro follows the diurnal cycle in the atmospheric humidity (minimum δ^{18}O and δD associated to minimum in humidity), which is what we expect. Contrary to the Picarro, the AP2E shows an opposition of phase between δ^{18}O and δD during March. Nevertheless, this does not permit concluding on the ability of the AP2E or Picarro analyser to measure at very low humidity levels, since the data shown here is only calibrated down to 50 ppmv. Further efforts should be put to constrain further the calibration in order to use the instruments at very low humidities.

Line 483 change “to correctly capture” with “in correctly capturing”

Modified.

Line 485-486 change “Because of the large correction linked to the humidity-dependence on the δ^{18}O signal, even the δ^{18}O could be challenged” with “Due to the significant correction associated with the humidity dependence of the δ^{18}O signal, even the δ^{18}O measurement could be questioned”

Modified.

Line 486-487 why you stopped the comparison at mid-February when you have data up to mid-March 2024? Is it because of the unreliability of the isotope data due to the very low humidity? I think it should be explained in the text

We decided to present the data until mid-March to show how the instruments agree at certain humidity levels and then start to diverge, and therefore only use the time period where both instruments are in good agreement to compare to the model. We explain this in the text l. 469-470. Further details are also given in our answer to Reviewer 2 comments n°5 and 40.

Line 490 change “show” with “shows”

Modified.

Line 491 change “including for the amplitude of the observed diurnal cycle” with “including in terms of the amplitude of the observed diurnal cycle”

Modified.

Line 495-496 change “the modelled δ^{18}O shows an overall positive bias during the period December to mid-February compared to the observations” with “the modelled δ^{18}O shows an overall positive bias during the entire period compared to the observations”

Modified.

Line 538 change “during the summertime” with “during summertime”

Modified.

Line 547-549 The higher deuterium excess in the measurements with respect to LMDZ6-iso could also be explained by sublimation

This is a very good point, and we added in the text a sentence to highlight this point as follows (l. 549-550):

[...] (coincides with higher humidity, δ^{18}O and δD levels). Fractionation during sublimation would also affect the d-excess in the water vapour and could partly explain the discrepancy between the observed and modelled diurnal cycle in d-excess. Including fractionation during sublimation could therefore improve [...]

Line 556-557 change “might not be well representing the in-situ conditions” with “they may not accurately represent the in-situ conditions”

Modified.

Line 570-571 change “Combining the observations of the water vapour isotopic composition” with “Combining observations of water vapour isotopic composition”

Modified.

Lauwers, T., Fourré, E., Jossoud, O., Romanini, D., Prié, F., Nitti, G., Casado, M., Jaulin, K., Miltner, M., Farradèche, M., Masson-Delmotte, V., and Landais, A.: OF-CEAS laser spectroscopy to measure water isotopes in dry environments: example of application in Antarctica, https://doi.org/10.5194/egusphere-2024-2149, 15 August 2024.

Grigioni, P., Camporeale, G., Ciardini, V., De Silvestri, L., Iaccarino, A., Proposito, M., and Scarchilli, C.: Dati meteorologici della Stazione meteorologica CONCORDIA presso la Base CONCORDIA STATION (Dome C), ENEA [dataset], https://doi.org/10.12910/DATASET2022-002, 2022.