

We thank both reviewers for their valuable comments, which we have worked to address below to improve the manuscript. The reviewers' comments are reproduced in blue and our answers are given in black.

### **Reviewer 1: Mathieu Casado**

This manuscript presents a synthesis of isotopic composition of atmospheric vapour, precipitation and sea water acquired during the EUREC<sup>4</sup>A campaign, near Barbados. The ambitious scale of the project, including seven vapour infrared spectrometers monitoring the vapour isotopic composition together on land, three ships and two aircrafts, created an invaluable set of timeseries which will be used to study convection in tropical environments.

The manuscript adequately reports the methods and carry out rigorous uncertainty evaluation. The huge dataset leads to a difficult to grasp ensemble of time series, and at times, the manuscript is difficult to follow, especially for people not involved in the project. It seems like the actual use of the produced data might be difficult: indeed, while the authors were careful to provide an exhaustive access to the data, which is commendable, the manuscript describes large part of the dataset that shouldn't be used, or should be used with care, but does not provide a flagged version of the dataset. Considering the size of the dataset, this might be excessively complicated to produce, but probably also reduces the reach of the dataset and the manuscript. Due to the high quality of the dataset and the post-treatment, validations, and uncertainty evaluation, I recommended to accept the manuscript after the following modifications have been implemented.

#### General Comments:

1. The manuscript really provides a complete overview of everything that has been measured. I agree that including easily accessible calibrated "relatively raw" datasets is great, so other scientists can in the future explore the datasets. But considering that the manuscript provides a detail overview of when the data shouldn't be trusted at face value, a flagged version of the dataset, or alternatively a filtered version of the dataset, would be useful to ensure that other users will not over-interpret data.

Response: All of the EUREC<sup>4</sup>A-iso datasets contain uncertainty estimates, which quantify our confidence in the measurements, quality control flags, and/or global quality control comments. Revisions to Sect. 3 of the main text (see next comment) highlight these dataset elements more clearly.

In addition, Table 3, which provides a summary of all the EUREC<sup>4</sup>A-iso datasets, has been revised to include information about quality control flagging (pointing readers to where to find the quality control information associated with each dataset more easily) and includes additional notes that highlight the most important data quality concerns.

We suspect the reviewer may have been particularly concerned with the quality of the BCO OA-ICOS dataset and the P-3 data at altitude. Of note, the BCO OA-ICOS dataset includes a README file warning potential data users about the suspected spectroscopic issue with the oxygen isotope ratio. Revisions to the main text now state more clearly that the CRDS dataset is the preferred BCO dataset. For example, Lines 786-789 in the revised text state: "While the BCO OA-ICOS values are similar to near-surface water vapor isotope ratios measured at sea...we are confident that the higher isotope ratios of the BCO CRDS system are more accurate and result from sea spray evaporation associated with wave breaking at Barbados' most windward point".

The P-3 1 s data files already contain two estimates of uncertainty (see Fig. 8 in the revision), both of which clearly show that measurement precision declines with decreasing water vapor concentration. Indeed, this is characteristic of all CRDS water isotopic systems (see, for example, the ATR analyzer uncertainties in Fig. 7 of the revision). Based on the perceived concerns of the reviewer, we have opted to include variable-specific comments in the P-3 isotopic data files that warn data users about the general tendency for isotopic measurement precision and accuracy to decline with lower water vapor concentrations and lower isotope ratios. These comments will appear in version 1.2 of the P-3 isotopic data.

Note that, unlike the high-altitude  $\delta^{18}\text{O}$  data from the P-3, which are flagged for being unphysical, the high-altitude  $\delta\text{D}$  data are scientifically useful and show meaningful qualitative differences flight-to-flight despite their high uncertainties.

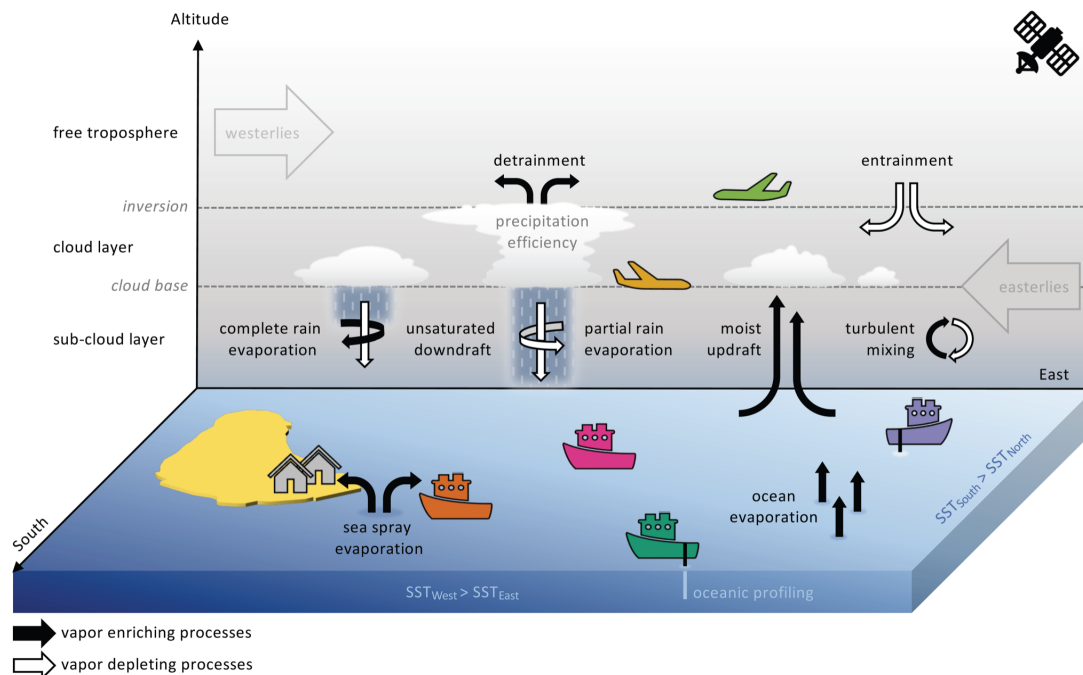
2. The general organisation seems relevant, but is sometimes difficult to follow due to the large number of details, and that the analysis and post-treatments were all realised differently, which is how it is. For the sake of using the data, and comparing the different datasets, the same key elements are needed though, regardless of how they were obtained. While the information is clearly provided here, if it was provided in a more systematic manner, it might help the reader.

Response: We have significantly revised Sects. 2-3 such that the same key elements are discussed in the same order for all platforms. For example, the water vapor data collections (Sect. 2) all now include a brief description of the platform's primary sampling strategy, followed by a streamlined description of the installation and inlet system, followed by a description of in-field calibration protocols. The precipitation data collections now all include information about how many samples were collected and whether samples represent discrete rain events or not. They also include similar details about in-field sample treatment and storage and state the laboratory where isotopic analysis was carried out. (If these details are not known, this has been stated.) The seawater collection descriptions now describe more clearly the similarities and differences in sampling strategies between platforms. Like the rainwater descriptions, they now include similar details about in-field sample treatment and storage and state the laboratory where isotopic analysis was carried out.

Section 3 begins with a revised paragraph that highlights key similarities in how the EUREC<sup>4</sup>A-iso datasets were processed. Sect. 3.1 begins with a new paragraph that describes the format by which post-processing is described specifically for the water vapor isotopic measurements. As stated therein, "for each platform, we discuss how in-field and/or pre- and post-campaign calibrations were used to normalize the data to the VSMOW-SLAP scale. We also describe how instrumental drift was evaluated and whether it required adjustments to the VSMOW-SLAP normalization over the course of the campaign. Moreover, we discuss the relevance of known biases associated with low water vapor concentrations...and report any post-processing of water vapor concentration data or adjustments to timestamps to account for time delays in the measurement systems".

Each post-processing description now also includes a clear statement of measurement uncertainty, describes the time resolution of the final data product, and alerts readers to flags or masks in the datasets.

Furthermore, to help make the EUREC<sup>4</sup>A-iso data collection less "difficult to grasp" and to provide readers with an overview of the water cycle processes one might study using the collection, we have included a new figure (Fig. 1), shown below:



Additional descriptions of data collection uses can be found in Sect. 6 “Concluding perspective on dataset uses”, which has changed little from the original submission.

#### Specific Comments:

- 1) Lines 46 to 47: “Moreover, water vapor isotope ratios were measured from a few meters to nearly 8 km above sea level.”  
While this is true, the quality of the vapour isotopic ratios measured above 5 km might not be sufficient to be used (see comment below). At this point, wouldn't it be fairer to provide the altitude range where you are confident of the trustworthiness of the dataset?

Response: The P-3 data from above 5 km are still useful and show meaningful qualitative differences flight-to-flight. Lower confidence in the data collected at these altitudes is characterized by the larger uncertainty estimates provided in the data files (see also Fig. 8 in the revision). Nevertheless, we have generalized the statement in the abstract to indicate that measurements were made to the mid-free troposphere.

- 2) Lines 83 to 85: “As a result, oxygen and hydrogen isotope ratios in vapor (i.e.  $^{18}\text{O}/^{16}\text{O}$ , D/H) lower with progressive condensation and rainout, while evaporation from the ocean (or another liquid reservoir) and subsequent moisture transport replenish the atmosphere with relatively heavy water. (Although the evaporative process itself discriminates against heavy water, the ocean is isotopically enriched relative to the atmosphere.)”  
This is a very complicated way to say that the vapour is more depleted than the ocean water, and gets more depleted in heavy isotope each time a precipitation event occurs.

Response: We have adopted your language suggestions and rephrased as follows: “Because isotope ratios (i.e.  $^{18}\text{O}/^{16}\text{O}$ , D/H) are sensitive to the integral of moist processes experienced by an air mass during transport (Gat 1996; Galewsky et al., 2016), they are an ideal tool for assessing the coupling between the circulation at large scales and moist processes at smaller scales (Fig. 1). This sensitivity stems from the fact that isotopically heavy and light water molecules change phase and diffuse at distinct rates, causing the heavier molecules to reside in greater relative abundance in the condensed phase. The result is that the atmosphere is depleted

of heavy isotopes relative to ocean water below and becomes further depleted as condensation and rainout occur. In contrast, evaporation from the ocean, and subsequent upward moisture transport, enriches the atmosphere isotopically (even though the evaporative process itself discriminates against heavy water). Evaporation also causes a shift in the hydrogen isotope ratio relative to the oxygen isotope ratio due to diffusive differences between the heavy isotopologues ( $\text{H}_2^{18}\text{O}$  and HDO) under non-equilibrium conditions”.

- 3) Lines 86 to 87: “One outcome is the ability to differentiate boundary layer and free tropospheric air and to quantify the exchange of moisture between these layers. “  
Can you really differentiate these solely based on the isotopic composition?”

Response: We have modified our claim as follows: “Isotope ratios can thus help differentiate between air masses that have experienced distinct water cycle histories (e.g. Noone et al., 2011; Hurley et al., 2012; Bailey et al., 2013; Aemisegger et al., 2021a) and test hypotheses about the processes responsible for setting air mass humidity and cloud states. Examples include evaluating the roles of air-sea exchange and rain re-evaporation in moistening the atmosphere (Fig. 1; Worden et al., 2007; Benetti et al., 2015; Aemisegger et al., 2015; Risi et al., 2020). As pseudo-conserved tracers, isotope ratios can also help characterize mixing between air masses that are isotopically distinct, such as the boundary layer and free troposphere (e.g. Noone et al., 2011; Bailey et al., 2013; Salmon et al., 2019). Indeed, while the isotopic signature of the free troposphere in subsidence-dominated regions like the trades is set primarily by conditions of last saturation (González et al. 2016; Galewsky and Hurley 2010), the isotopic composition of the boundary layer is largely regulated by air-sea interactions and shallow moist convective processes (Benetti et al. 2015; Risi et al. 2020). Mixing between these atmospheric layers produces predictable variations in the isotope ratio as a function of water vapor concentration (Noone et al. 2011; Noone 2012)”.

- 4) Lines 86 to 94: For this whole part of the paragraph, I would say that the description is a little bit optimistic. Water isotopic composition is an integrated variable that is sensitive to all the phase transitions, as well as to diffusion and mixing of air masses, which means that under some assumptions, you would be able to test hypothesis about the history of the air masses, and in particular, which processes to moistening them.

Response: Please see the response above.

- 5) Lines 99 to 100: “We will also use the deuterium excess parameter, defined as  $d = \delta\text{D} - 8 \times \delta^{18}\text{O}$ , to describe variations in one isotope ratio relative to the other.”  
The definition of d-excess seems limited. Why 5 then? I guess maybe considering changing for “To describe relative variations of both isotopes which do not follow the “meteoric water line”.”

Response: To clarify, we are not defining deuterium excess as variations in one isotope ratio relative to another but simply stating that we use the deuterium excess to characterize these variations. Deuterium excess is defined by the formula provided, for which we have added Dansgaard (1964) as a reference.

- 6) Lines 104 to 105: “A total of seven water vapor isotopic analyzers, sampling at 0.5 Hz or faster, were deployed during the campaign on two research aircraft”

The 0.5 Hz sampling rate seems peculiar and an explanation of why could this be important is probably needed.

Response: We have emphasized the sampling rate of the sensors in order to provide a sense of the scale of the measurements during the EUREC<sup>4</sup>A deployment, which is the main purpose of this paragraph. The 0.5 Hz acquisition rate you have flagged corresponds to the older isotopic analyzers deployed during EUREC<sup>4</sup>A (e.g. the Picarro L2120-i deployed at the BCO). In comparison, the L2130-i instruments deployed on the ATR and P-3 were designed in close exchange with Picarro for dedicated aircraft measurements. They feature increased flow rates of up to 0.6 SLPM and increased data acquisition rates of 1-5 Hz, which are necessary to capture higher frequency signals.

I presume it is for the processing of the aircraft measurements, but clearly, when seeing the performances of the BCO infrared spectrometers, from the same inlet, at high sampling rate, it seems like there is very limited “climatic interpretation” for data with 0.5 Hz sampling rate.

Response: EUREC<sup>4</sup>A-iso is focused on elucidating processes related to shallow convective cloud formation that are otherwise difficult to evaluate with traditional instrumentation (see new Fig. 1). These processes act at turbulent to synoptic timescales (1 s to 1 day) and at cloud- to meso-scales (10 m to 10<sup>5</sup> m). For this reason, we feel that providing our data at relatively high time resolutions (1 s to 1 min) is not only warranted but also essential. (Keep in mind that a 1 second average on the aircraft represents a footprint of about 100 m. A 1 minute average would represent a footprint of >7 km!) The focus of EUREC<sup>4</sup>A-iso also differs dramatically from climatic applications that typically use water isotopic information on hourly, daily, or even monthly timescales.

Overall, it seems like there is a dichotomy between the measurements which took place in certain conditions, and the data which are meaningful only in subset of the range of observed conditions. In the case of the resolution of the produced data, it seems like the recommendation would be to use them at a resolution of several minutes or an hour?

Response: We have provided the non-flight data at 1 or 2 minute resolution and the flight data at 1 s resolution, since these are the resolutions we think are most useful for pairing the isotopic data with other meteorological measurements to study the shallow convective environment of the trade winds. For those desiring additional information, Sect. 2 now includes estimates of measurement response (time delay) for each water vapor isotopic analyzer.

While in some cases, the estimated measurement response time may be slightly larger than the time resolution at which the data are produced (e.g. 10 s v. 1 s for the ATR), consider the fact that many of the major observational facilities customarily report data at a particular time resolution, even if the individual measurements are not fully independent at this frequency. Indeed, most airborne platforms customarily report 1 s data even if the individual data points are not fully independent at this resolution. To facilitate the joint use of the isotopic data with other meteorological data, we have tried, where possible, to produce datasets with a time resolution that matches other data from the same observing platform.

7) Lines 143 to 144: “The BCO water vapor isotopic measurements were set up to serve as a high-frequency (1 minute) reference dataset at a location with extensive meteorological in situ and remote sensing observations,”

I agree with the statement that 1 minute is high frequency measurement in the case of atmospheric boundary layer dynamic. But then, this is very slow compared to the 0.5 Hz mentioned in the introduction.

Response: Yes, despite the 0.5 Hz data acquisition rate, we recommend using the data at 1 min time resolution, in the case of the BCO datasets, to take advantage of the optimal precision of the data. We have removed “high frequency”, since, indeed, in terms of boundary layer turbulence, 1 min is rather slow. We have changed the text as follows: “The BCO water vapor isotopic measurements were set up to serve as a reference dataset at 1 minute time resolution at a location with extensive meteorological in situ and remote sensing observations...”

8) Lines 424 to 425: The uncertainties given here are very surprising, in particular compared to the values given lines 413 to 414. Is this due to the rather old model of the Picarro analyser?

Response: We realize that there might be a source of confusion here. The indicated precision of the calibration (originally at Lines 413-414; now Line 454) relates to an averaging time window corresponding to the length of the calibration run (thus 10 to 30 minutes). The total uncertainty for the processed isotopic data, indicated in Lines 472-474 of the revision, is also affected by the precision of the measurement at 1 minute time resolution, the drift correction, and the uncertainty associated with the isotopic composition of the liquid standards. For reference, these uncertainties are comparable to what we obtained in previous deployments at the BCO and other sites (Aemisegger et al., 2021; Aemisegger et al., 2014; Aemisegger et al., 2012). To help clarify, we have added to the text the time resolution of the measurement to which the uncertainty corresponds.

One of the messages we hope to convey in this manuscript is that uncertainty estimates associated with water vapor isotopic sampling are typically much larger than factory-reported precision estimates, largely due to errors in generating reference gas from a liquid standard, in fitting the normalization correction function, and in characterizing biases associated with low water vapor concentration. The EUREC<sup>4</sup>A water vapor isotopic datasets attempt to account for all of these possible sources of uncertainty.

9) Lines 431 to 432: “The effect of this oscillation is not included in the OA-ICOS analyzer’s isotopic uncertainty estimates.”

If the effect of an oscillation that seems to be an artefact is not included in the uncertainty estimates, the datapoints should be flagged out.

Response: Due to the difficulty of knowing exactly when the oscillation affected measurements or not (and therefore of flagging these points), we have opted instead to report all BCO OA-ICOS  $\delta^{18}\text{O}$  measurements as suspect. This is done in the README file archived with the datafiles and now, based on your concern, also in Table 3.

10) Lines 490 to 495: This is very confusing. Wouldn’t the difference between the correction functions obtained in the field vs the ones derived post campaign be related to accuracy while the standard deviation at 1Hz be linked with precision?

Response: Variations in the P-3 normalization functions obtained in the field were the result of our inability to generate reference gas precisely (i.e. with repeated reliability) not due to an inaccuracy (i.e. a bias). That said, given the confusion this paragraph created, we have revised it and amended our recommendation. Because the standard deviations reported in the 1 s P-3 files are about twice the uncertainty estimated from calibration checks, we recommend data users use the standard deviations as a more conservative estimate of total uncertainty.

11) Lines 679 to 684: “Surprisingly, the BCO’s two analyzers are 1.5 and 4.5‰ different in  $\delta^{18}\text{O}$  and  $\delta\text{D}$ , respectively, even though they sampled from the same inlet and were calibrated using the same standards and procedure. This unexpected discrepancy highlights the challenge of accurately estimating biases and uncertainties in water vapor isotopic field measurements using typical calibration approaches and suggests it may be necessary to measure a larger number of standards or to measure the standards for longer periods while in the field.”

Isn’t these results contradicting with the uncertainty propagation? These values are larger than the ones shown in section 3.1, and thus, would suggest that the uncertainties are clearly underestimated. This is furthermore problematic that these values are of the same order of magnitude than the daily and synoptic variations.

Response: We agree that uncertainties estimated from traditional calibration procedures are likely underestimated, and we have made this point throughout the text. Based on continued exploration of the data, we believe the source of the discrepancy most likely stems from a water vapor concentration dependency in OA-ICOS analyzers that is apparent even at high humidity levels (cf., Sturm and Knohl, 2010). We have newly noted this possibility in Sect. 3.1 and 4.1.1 (e.g., Lines 789-791 of the revision state: “The lower isotope ratios of the BCO’s OA-ICOS analyzer likely reflect an uncorrected water vapor concentration bias that can be significant for OA-ICOS systems even at high humidity levels (Sturm and Knohl, 2010)”). Unfortunately, due to problems with the calibration system at the BCO we could not perform the necessary water vapor mixing ratio dependency tests in the field to characterize the humidity dependence of the OA-ICOS analyzer deployed and bias-correct for it.

We believe the “missing” humidity dependent correction manifests itself as a humidity-dependent difference between the CRDS and OA-ICOS data (see new Fig. S3-S4 below, which have been added to the Supplemental Information). From a previous deployment of the same OA-ICOS system on the Azores, we estimate that the amplitude of such a correction (Galewsky, 2021, <https://www.arm.gov/publications/programdocs/doe-sc-arm-19-027.pdf>) could lead to a shift in  $\delta\text{D}$  of about 3‰ and a shift in  $\delta^{18}\text{O}$  of about 1‰ at the humidity levels measured at the BCO (this is now stated in the revisions to Sect. 4.1.1). Note that adjustments of this magnitude would bring the OA-ICOS time series to within the uncertainty band of the CRDS time series (see new Fig. S4-S5 below, which have been added to the Supplemental Information).

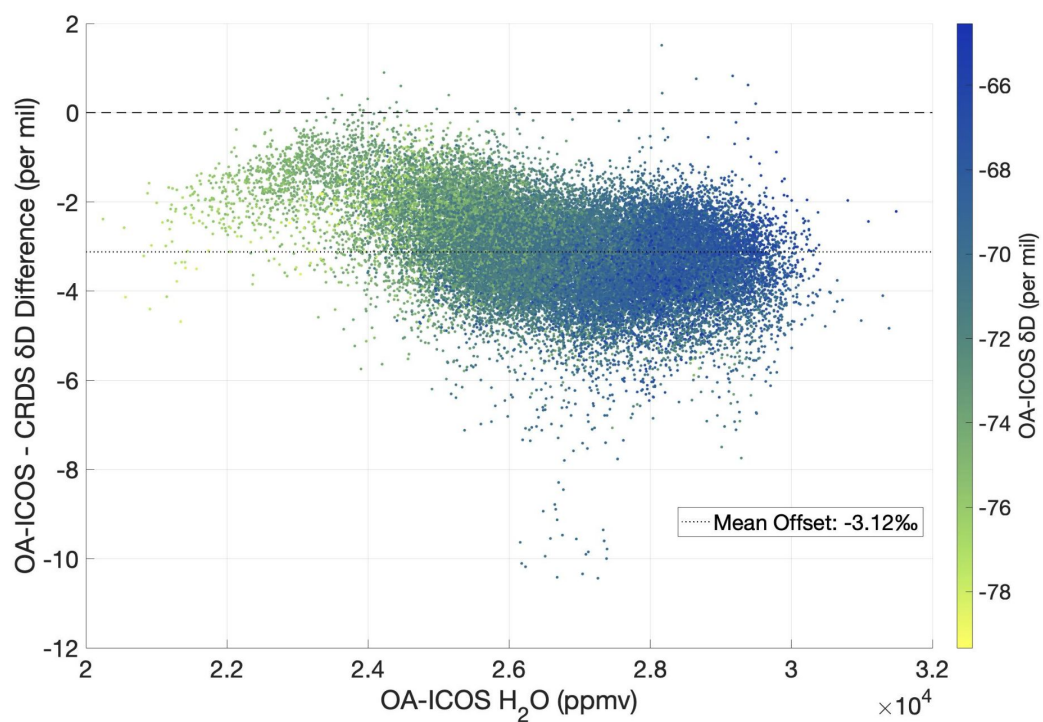


Figure S3: OA-ICOS-CRDS differences in  $\delta D$  (y-axis) as a function of the OA-ICOS water vapor concentration (x-axis). Shading shows the OA-ICOS (normalized and drift-corrected)  $\delta D$  value in units ‰.



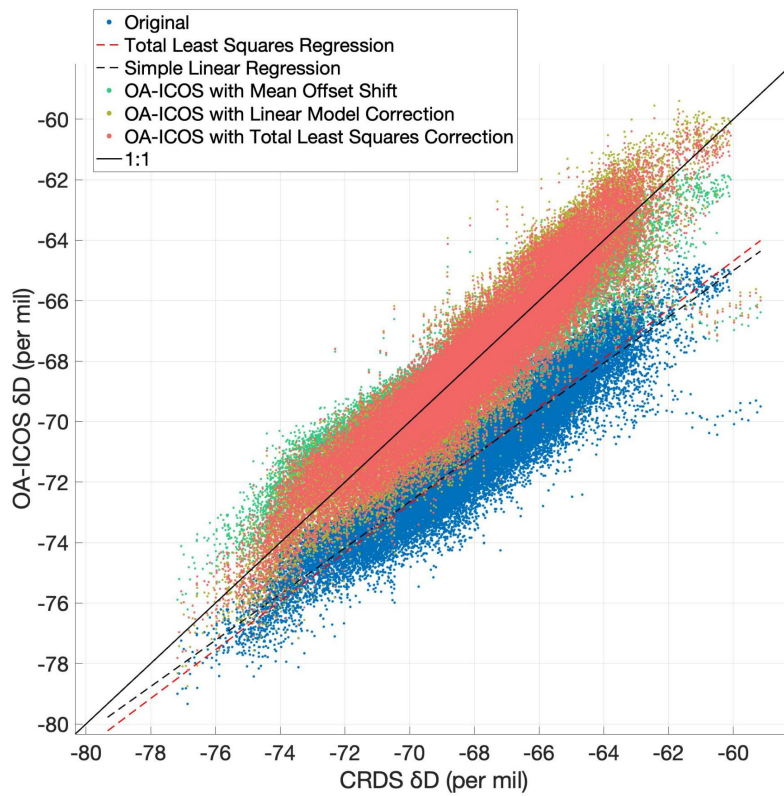


Figure S4: The scatterplot shows the original relationship between the (normalized and drift-corrected) OA-ICOS and CRDS  $\delta D$  values (blue dots). It also shows how the relationship shifts towards the 1:1 line (black, solid) when the OA-ICOS data are scaled by one of three methods: a simple offset (green dots), a simple linear regression (red dashed line, gold dots), or a total least squares regression (black dashed line, orange dots).

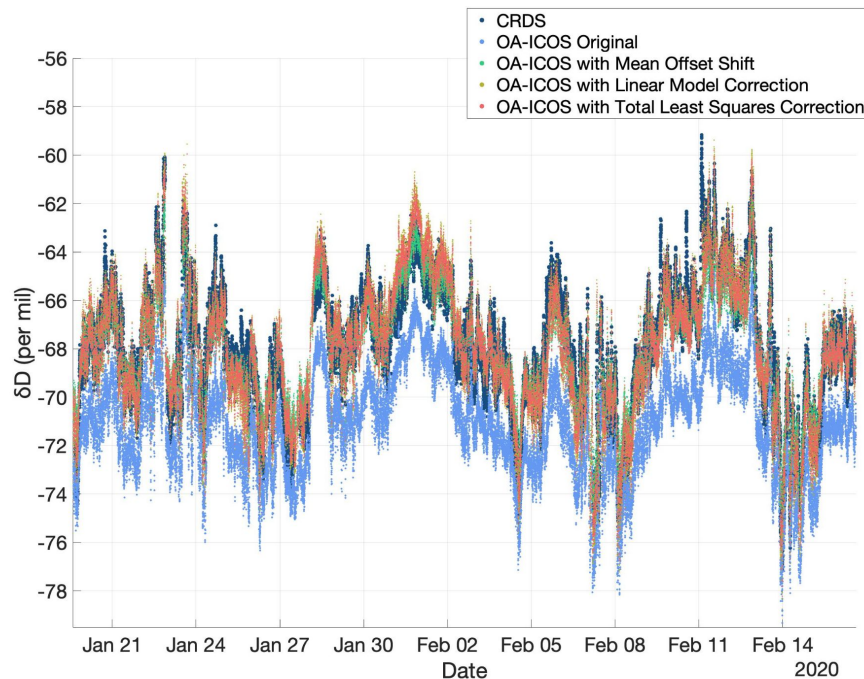


Figure S5: After scaling the original OA-ICOS data (light blue dots) to the CRDS data by one of the methods illustrated in Fig. S4, the adjusted  $\delta D$  (‰) time series (green, gold, or orange dots) converges with the CRDS  $\delta D$  time series (dark blue dots).

Despite differences in the absolute values between the CRDS and OA-ICOS systems at the BCO, we insist that there are very high correlations between the signals measured by the two instruments for  $q$  and  $\delta D$ . The artificial oscillations in the  $\delta^{18}O$  measured by the OA-ICOS prevent us from using the oxygen isotope ratios in a similar comparison.

12) Lines 686 to 689: “Despite their sizable mean offsets, time series from the two BCO analyzers are strongly correlated for both water vapor concentration and  $\delta D$ , bolstering our confidence in the variability captured in their respective signals (Fig. 11, Table 2). (Correlation between the  $\delta^{18}O$  time series is diminished by the oscillation in the OA-ICOS signal but can be increased by applying a low pass filter or averaging to longer time steps.)” The correlation of 0.94 between the  $\delta D$  of the BCO CRDS and BCO OA-ICOS appears at odds with Figure 11. Since the dataset stored at Galewsky, J. (2020). BCO OA-ICOS Water Vapor Isotopic Composition. [Dataset]. Aeris. <https://doi.org/10.25326/309> is faulty, it was impossible to reproduce the calculation. Did you evaluate the correlation on hourly resolved data ?

**Response:** We do not understand why the correlations reported in Table 2 (which represent 1 hourly smoothed data with 1 minute resolution) are at odds with the BCO time series comparison figure (Fig. 12 in the revision). As stated above, despite differences in the absolute values between the CRDS and OA-ICOS systems at the BCO, both analyzers capture the same environmental variability; hence, their high correlations.

Below in Fig. R1 we show the correlation between the CRDS and the OA-ICOS signals for different averaging windows.

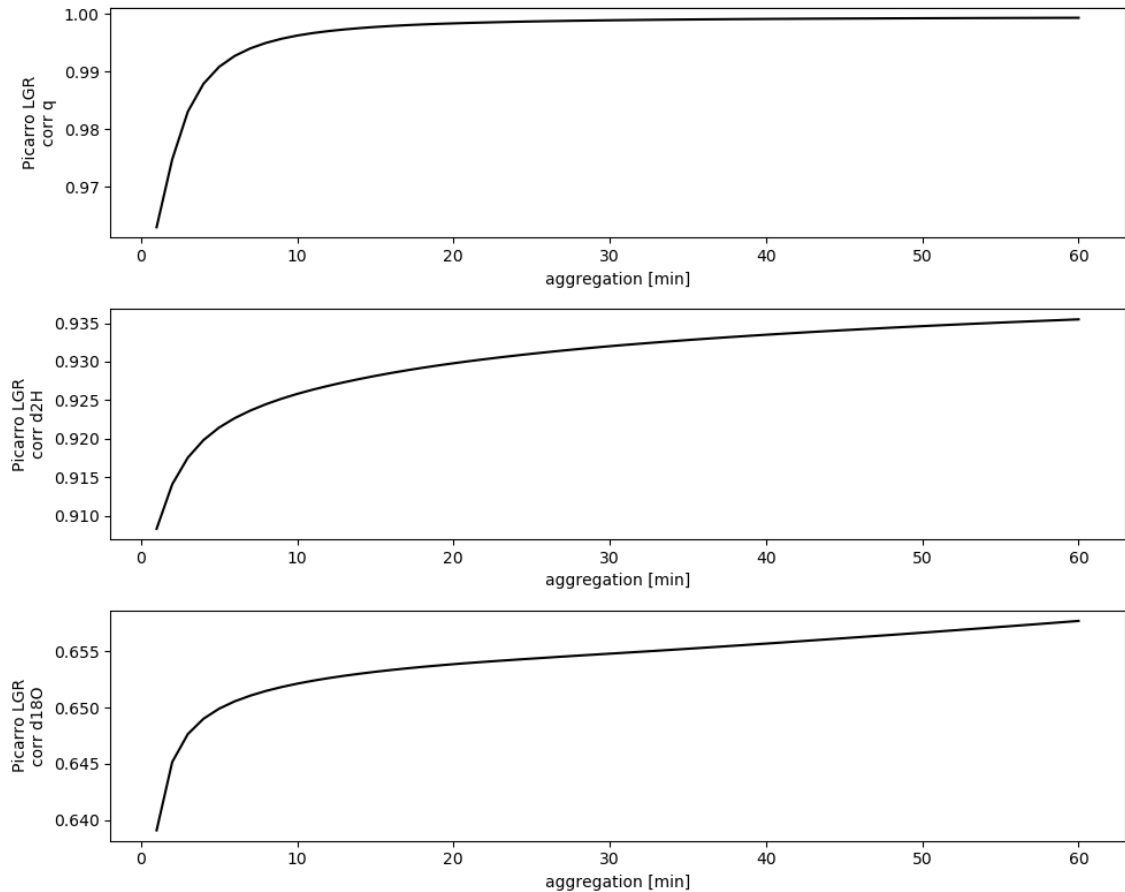


Figure R1: Pearson correlations for different time windows (aggregation in minutes, x-axis) for the specific humidity  $q$ ,  $\delta D$  and  $\delta^{18}O$  (y-axes) measured by the Picarro CRDS system and the LGR OA-ICOS system at the BCO.

If you compare to (Leroy - Dos Santos et al., 2020), where two instruments were measuring from two different inlets, and located at neighbouring site, almost 4km away, and with a difference of 470m of altitude, the correlations are larger than 0.9 for humidity and d18O. In your case, it with such large difference for both instruments measuring from the same inlet, either one or both are faulty.

**Response:** We believe that there is a misunderstanding here: the difference between the CRDS and OA-ICOS time series in absolute values and the correlations are two independent measures of agreement. Yes, we do observe an offset between the CRDS and the OA-ICOS time series at the BCO, which, as explained above, we believe is due to a bias introduced in the OA-ICOS system because of the missing water vapor concentration correction. However the correlation between the two instruments is excellent for  $q$  and  $\delta D$  as can be seen in new Fig. S5 above.

Furthermore, please note that the BCO comparison is between two laser spectrometers that use a different technology and different absorption peaks (one OA-ICOS system and one CRDS system). We now draw readers' attention to this fact at the end of the first paragraph of Section 2.1.1: "The two systems operate at different wavelengths in the infrared; consequently, baseline effects due to varying water vapor concentrations can affect the measurements differently (Johnson and Rella, 2017)".

Comparing two CRDS analyzers (such as in Leroy - Dos Santos et al., 2020) is different because it can potentially mask biasing effects that affect the analyzers in the same way, such as baseline effects due to the presence of other gases (Johnson and Rella, 2017).

It is essential to investigate which of the two datasets is to be trusted, and potentially at which resolution, because clearly here, the 0.5 Hz data do not contain climatic signal.

Response: We agree and have worked to provide more clarity in this regard in the revised version, emphasizing the trustworthiness of the CRDS data. That said, we would like to point out that there is much to be learned about shallow cumulus cloud formation – from the timescale of individual updrafts to transitions between different cloud patterns at the synoptic timescale – from the BCO's isotopic variability. The fact that the two isotopic analyzers at the BCO agree so well in their ability to capture this variability gives us high confidence that we are able to resolve the shallow convective processes we are interested in. This is one reason we feel that making both datasets publicly available is valuable.

To further emphasize the strong coherence between the two BCO analyzers, new Fig. S4 (replicated above) shows a scatter plot relating the OA-ICOS and CRDS data and illustrates how correcting the OA-ICOS data towards the CRDS data with different methods (e.g. mean offset shift, linear model correction, total least squares correction) leads to an agreement of the two signals within their uncertainty range. New Fig. S5 shows the time series corresponding to these corrections. Both figures have been added to the Supplemental Information.

The correlation between the BCO OA-ICOS and the meteor (and with the other available datasets when they were nearby) could be useful, because it appears that the agreement is actually better for both  $dD$  and  $dexcess$  than between BCO CRDS and BCO OA-ICOS, excluded the periods with the weird  $d18O$  oscillations.

Response: The correlations between the OA-ICOS and the instruments on the ships are similar to the ones between the CRDS and the ships (given the very high correlations between the OA-ICOS and the CRDS; Table 2). The offset between the OA-ICOS and the ships is indeed a bit less than between the CRDS and the ships. But given the missing water vapor mixing ratio correction in the OA-ICOS data, this might be a coincidence. We attribute the more enriched isotope signals from the CRDS at the BCO to the contribution of sea spray evaporation from waves breaking on the reef and at the cliff just in front of the BCO. This contribution was likely much smaller on the ships. We have added this explanation to Section 4.1.1.

This part is a key weakness of the manuscript, and would really justify an additional effort to provide a safe dataset.

Response: Strong agreement in absolute value between the two BCO analyzers would, of course, have been preferred. However, their disagreement presents a rare opportunity to highlight the challenges associated with characterizing and correcting for biases and estimating related uncertainties. As mentioned above, the revised text (Sect. 4.1.1) now clearly encourages data users to trust the absolute values of the CRDS system over the OA-ICOS one.

## **Reviewer 2:**

The manuscript presents the data collected during the EUREC4A-iso measurements, a sub-part of the EUREC4C field campaign dedicated to isotopic measurements.

I find this manuscript very well written, with clear depictions of the various isotopic measurements. I do not have strong concerns about this manuscript, and believe that this manuscript could be published after the really minor comments below have been taken into consideration.

1) Remark : the unit “nmi” is used for distance, but is non-SI. A SI unit should be used.

Response: We have replaced nautical miles with distance estimates in km everywhere.

2) Line 85-90 : I do not understand how isotope ratios can help differentiate boundary layer air and free tropospheric air. It seems to be a shortcut, but this shortcut is not straightforward. Please explain.

Response: As noted above, we have modified the main text as follows: “Isotope ratios can thus help differentiate between air masses that have experienced distinct water cycle histories (e.g. Noone et al., 2011; Hurley et al., 2012; Bailey et al., 2013; Aemisegger et al., 2021a) and test hypotheses about the processes responsible for setting air mass humidity and cloud states. Examples include evaluating the roles of air-sea exchange and rain re-evaporation in moistening the atmosphere (Fig. 1; Worden et al., 2007; Benetti et al., 2015; Aemisegger et al., 2015; Risi et al., 2020). As pseudo-conserved tracers, isotope ratios can also help characterize mixing between air masses that are isotopically distinct, such as the boundary layer and free troposphere (e.g. Noone et al., 2011; Bailey et al., 2013; Salmon et al., 2019). Indeed, while the isotopic signature of the free troposphere in subsidence-dominated regions like the trades is set primarily by conditions of last saturation (González et al. 2016; Galewsky and Hurley 2010), the isotopic composition of the boundary layer is largely regulated by air-sea interactions and shallow moist convective processes (Benetti et al. 2015; Risi et al. 2020). Mixing between these atmospheric layers produces predictable variations in the isotope ratio as a function of water vapor concentration (Noone et al. 2011; Noone 2012)”.

3) Lines 660-665 : Does this part refers to Figures 9 and 10 ? The titles of these 2 figures (9 and 10) only states “campaign-mean (...)”. The 3 vessels (Atalante, Meteor and Brown) didn’t have the same legs, so I wonder how campaign-means can be reasonably used to look at the consistency between the measurements : there are differences in the length of the measurement period, and there are differences in the areas that have been sampled. Can you comment ?

Response: Indeed the platforms did not sample at the same location over the same time window, which implies that natural variability as well as measurement uncertainties contribute to the differences observed in the campaign means across platforms. Nevertheless, showing and intercomparing campaign means is a sensible way to present a large amount of data in a compact way. We have revised the beginning of Section 4.1.1 as follows: “given the integrative nature of water vapor isotope ratios (e.g. Moerman et al., 2013) and the relatively long duration each analyzer sampled, we expect average isotopic differences across platforms to be dominated by spatial variability”.

4) Note : Figure 10 is not referenced in the text.

Response: Thank you for catching this typo. You will now find the first reference to original Fig. 10 (Fig. 11 in the revision) on line 767. Additional information about the figure is now included in the paragraph beginning on Line 775 in the revision: “Cross-platform coherence in rainwater improves further if the BCO samples from the trailing cold front (22 January; DOY 22) are also excluded from the campaign-mean averages (open symbols; Fig. 11). Because rain on the 22

January was associated with large-scale convergence, its isotope ratios are much lower than samples representing typical shallow convective showers...”

5) [Figure 13: the unit of dD is missing.](#)

Response: The unit has been added to the caption.

### **Additional modifications**

Additional modifications have been made to the main text and Supplemental Information based on continued analysis of the data. In particular, we have found that high isotope ratio spikes in the Meteor water vapor isotopic time series may coincide with cold pool processes rather than evaporation of moisture from the ship’s decks and surfaces (see Lines 618-622 in the revision and revised Fig. S7).

BCO precipitation samples do not show evidence of post-sampling evaporation, as we had first suspected (see revisions to Sect. 3.2). Instead, we find that frontal rain appears to be isotopically distinct from shallow convective showers due to differences in rain formation and post-condensational exchange processes (see new paragraph starting at Line 775). We have highlighted this by adding a new open symbol to Fig. 11 in the revision.

Table 2 numbers have been updated using the latest versions of the published datasets with 1 hourly smoothing consistently applied.

The BCO time series comparison (Fig. 12 in the revision) has also been updated with the latest versions of the published data.

The near-surface water vapor values shown in Fig. 10 in the revision and the map of the sampling tracks (Fig. 2 in the revision) have been updated to reflect the latest published revision of the Meteor dataset.

The timeline plot (Fig. 3 in the revision) has been updated to include an Atalante rainwater sample that was missing from the original figure.

The paragraph concluding Sect. 4.2 has been modified for technical accuracy.

The water vapor correction function for the P-3 in the Supplemental Information (Eq. S3) has been fixed for a typo in the original submission.

Finally, we have updated citations, fixed a few grammatical errors, and made a few minor stylistic changes.

Thank you for your time and consideration.

### **References**

Aemisegger, F., Vogel, R., Graf, P., Dahinden, F., Villiger, L., Jansen, F., Bony, S., Stevens, B., and Wernli, H.: How Rossby wave breaking modulates the water cycle in the North Atlantic trade wind region, *Weather Clim. Dynam.*, 2, 281–309, <https://doi.org/10.5194/wcd-2-281-2021>, 2021.

Aemisegger, F., Sturm, P., Graf, P., Sodemann, H., Pfahl, S., Knohl, A., and Wernli, H.: Measuring variations of  $\delta^{18}\text{O}$  and  $\delta^2\text{H}$  in atmospheric water vapour using two commercial laser-based spectrometers: an instrument characterisation study, *Atmos. Meas. Tech.*, 5, 1491–1511, <https://doi.org/10.5194/amt-5-1491-2012>, 2012.

Aemisegger, F., Pfahl, S., Sodemann, H., Lehner, I., Seneviratne, S. I., and Wernli, H.: Deuterium excess as a proxy for continental moisture recycling and plant transpiration, *Atmos. Chem. Phys.*, 14, 4029–4054, <https://doi.org/10.5194/acp-14-4029-2014>, 2014.

Galewsky, J.: Water Vapor Isotopic Composition from the Azores Field Campaign Report, DOE/SC-ARM-19-027, <https://www.arm.gov/publications/programdocs/doe-sc-arm-19-027.pdf>, 2021.

González, Y., Schneider, M., Dyroff, C., Rodríguez, S., Christner, E., García, O. E., Cuevas, E., Bustos, J. J., Ramos, R., Guirado-Fuentes, C., Barthlott, S., Wiegeler, A., and Sepúlveda, E.: Detecting moisture transport pathways to the subtropical North Atlantic free troposphere using paired  $\text{H}_2\text{O}$ - $\delta\text{D}$  in situ measurements, *Atmos. Chem. Phys.*, 16, 4251–4269, <https://doi.org/10.5194/acp-16-4251-2016>, 2016.

Johnson, J. E. and Rella, C. W.: Effects of variation in background mixing ratios of  $\text{N}_2$ ,  $\text{O}_2$ , and Ar on the measurement of  $\delta^{18}\text{O}$ - $\text{H}_2\text{O}$  and  $\delta^2\text{H}$ - $\text{H}_2\text{O}$  values by cavity ring-down spectroscopy, *Atmos. Meas. Tech.*, 10, 3073–3091, <https://doi.org/10.5194/amt-10-3073-2017>, 2017.

Noone, D. Pairing Measurements of the Water Vapor Isotope Ratio with Humidity to Deduce Atmospheric Moistening and Dehydration in the Tropical Midtroposphere, *Journal of Climate*, 25(13), 4476–4494, 2012.

Sturm, P. and Knohl, A.: Water vapor  $\delta^2\text{H}$  and  $\delta^{18}\text{O}$  measurements using off-axis integrated cavity output spectroscopy, *Atmos. Meas. Tech.*, 3, 67–77, <https://doi.org/10.5194/amt-3-67-2010>, 2010.