Answer to Reviewer 1.

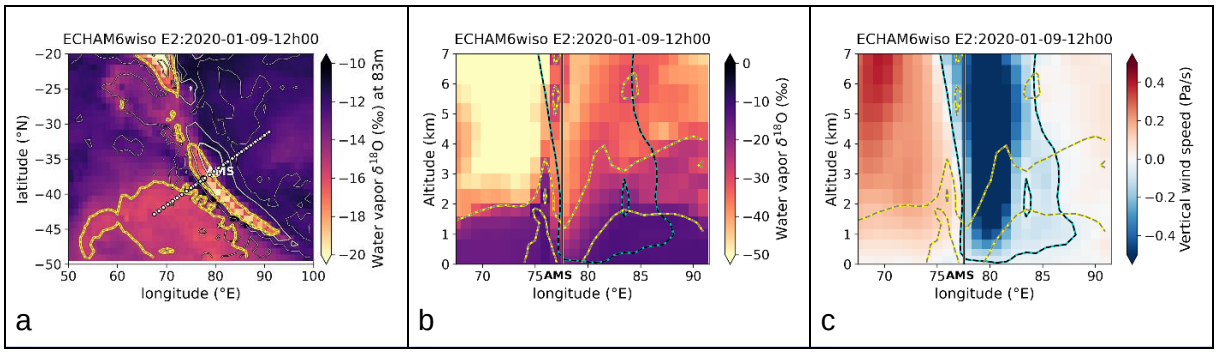
Many thanks for the additional comments. We have addressed the different comments as detailed below.

Thank you for the detailed replies. Many of my concerns have been addressed and I think that this manuscript fits to ACP, especially when highlighting that the combination with mercury measurements allows for new conclusions regarding vertical air movements. I think that in the new manuscript, this message is improved. But mercury is only marginally mentioned in the introduction. There are many explanations in the data section which might better motivate the study if included in the introduction.

>> We have added an additional sentence in the introduction :
« Indeed, previous studies have shown that gaseous elemental mercury decreases with increasing altitude in marine environment suggesting that gaseous elemental mercury can be used as a tracer of subsidence of air from the high altitude (e.g. Koening et al., 2023). »

I still have some concerns regarding the interpretation of the cold front dynamics and the figures highlighting these dynamics. Even though the term “cold front” is less dominant throughout the manuscript, the cold front dynamics are still prominent in the conclusion and synthesis figure. This makes sense as most of the d18O excursions are related to the passage of a cold front. But Figures 8, 9, S2 and S3 show a very wide longitudinal range that does not allow to see features along the cold fronts.

We agree that it makes sense to zoom closer to the front location and we modified Figures 8, 9, S2 and S3 accordingly. As fronts are usually oriented in the North-West/South-East direction, we also changed the cross sections to be oriented perpendicular to this direction, as shown below in new Fig. 8 and in new Fig. S1.



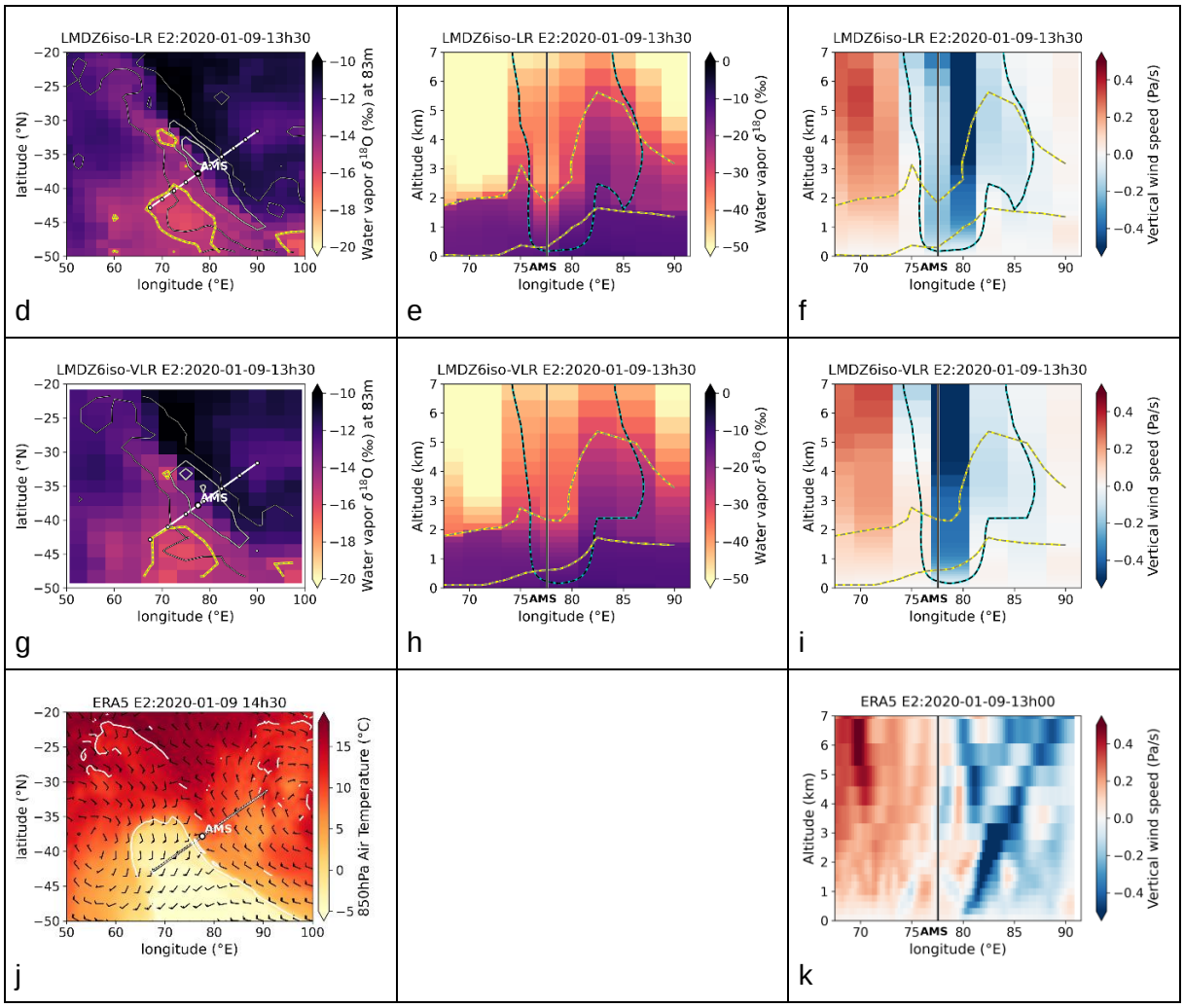
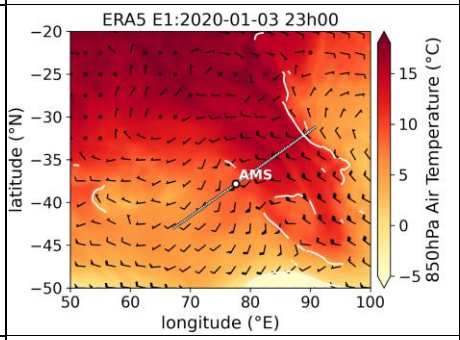
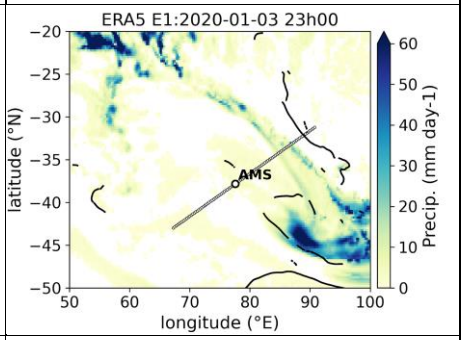
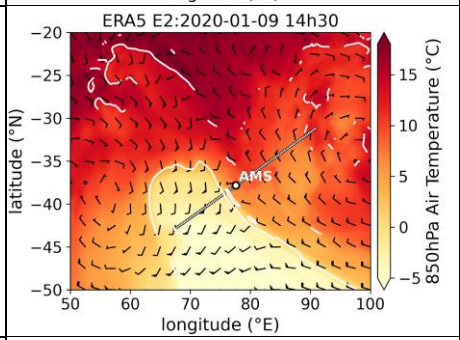
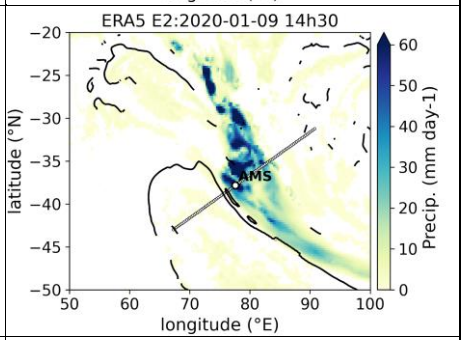
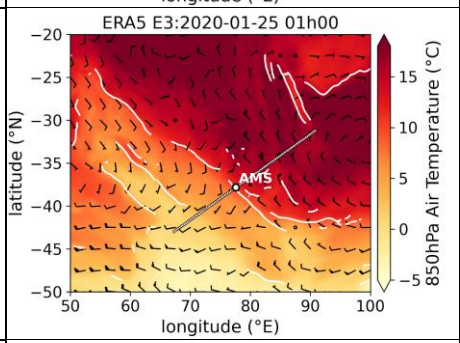
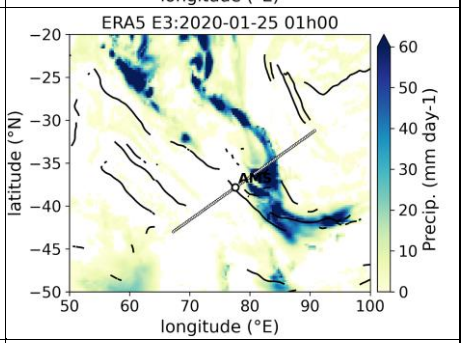
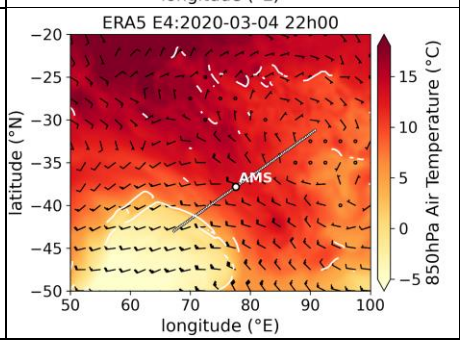
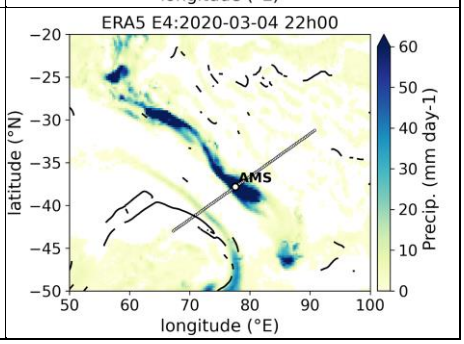
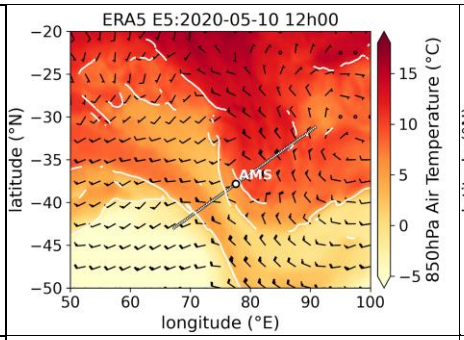
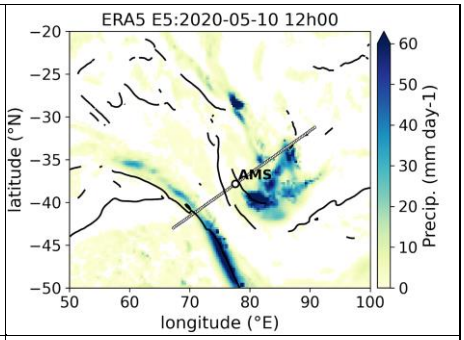
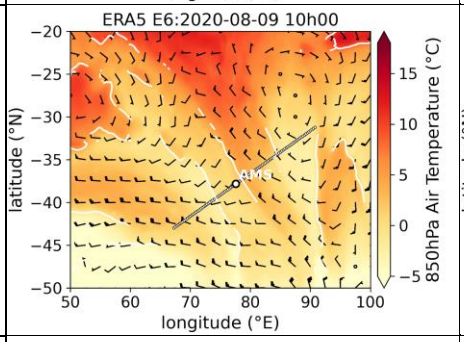
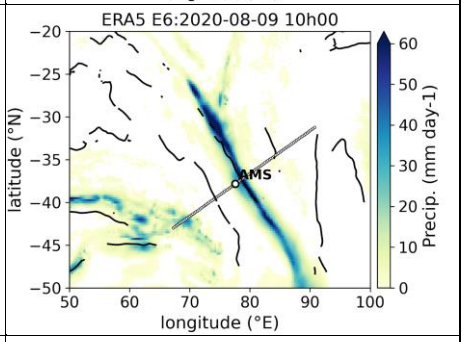
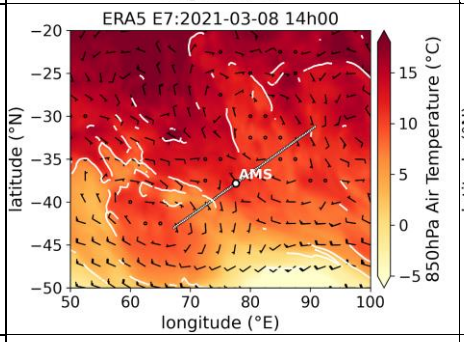
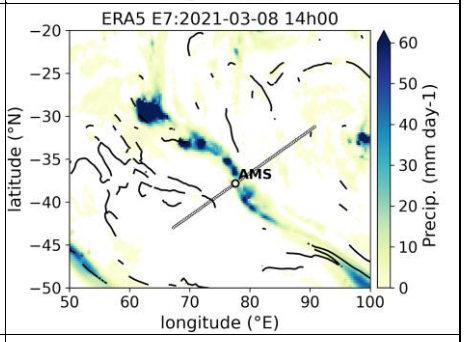
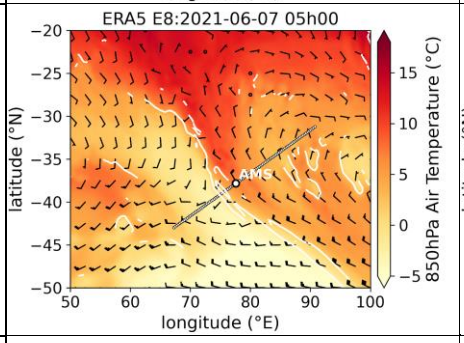
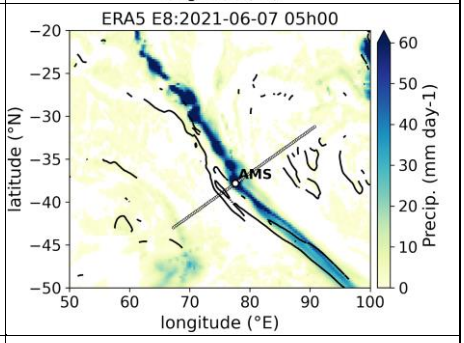
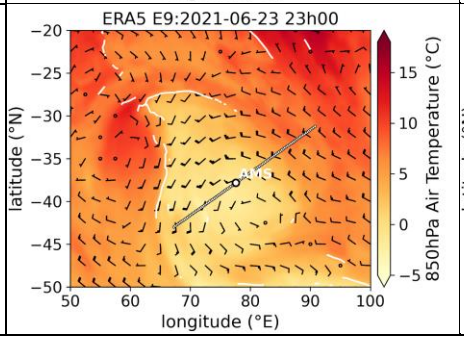
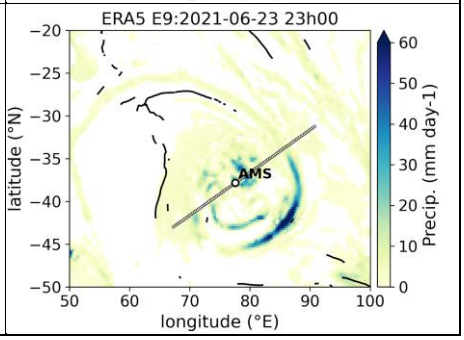


Figure 8: Modelled $\delta^{18}O_v$ and vertical velocity for the event of January 9th 2020. (a) Surface air $\delta^{18}O_v$ (~83 m, latitude vs longitude), with yellow line indicating -15 ‰ contour level and grey lines indicating precipitation contours at 0.5, 10, and 50 mm day^{-1} (thin, medium and thick lines respectively); (b) $\delta^{18}O_v$ plotted on a vertical cross-section (altitude vs longitude) along the transect indicated by the white line on panel (a), with yellow lines indicating $\delta^{18}O_v$ contours at -30 ‰ and -15 ‰, blue lines indicating the contour of –0.05 Pa s^{-1} vertical velocity (ascendance), and the vertical black line denoting the longitude of Amsterdam Island; (c) Vertical velocity plotted on a vertical cross-section as for (b), with same contour lines. (a), (b) and (c) are drawn using outputs of the ECHAM6-wiso model; (d), (e) and (f) are the same as (a), (b) and (c) but obtained from the LMDZ-iso model at low resolution (LR); (g), (h) and (i) are the same as (a), (b) and (c) but obtained from the LMDZ-iso model at very low resolution (VLR). (j) ERA5 air temperature at 850 hPa, with white lines marking front locations (see Supplementary Material S1); (k) ERA5 vertical velocity plotted on a vertical cross-section (altitude vs longitude) along the transect indicated by the black dotted line on panel (j)."

Date of events	(a) Air temperature at 850 hPa	(b) Precipitation
03/01/2020		
09/01/2020		
24/01/2020		
04/03/2020		

10/05/2020		
09/08/2020		
08/03/2021		
07/06/2021		
23/06/2021		

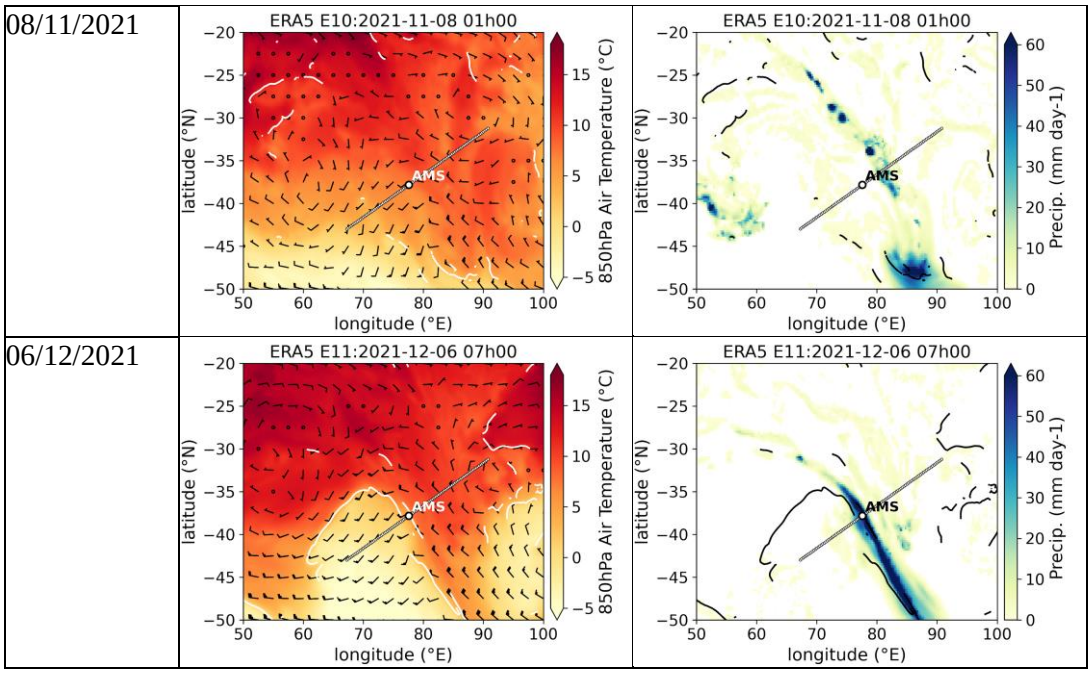
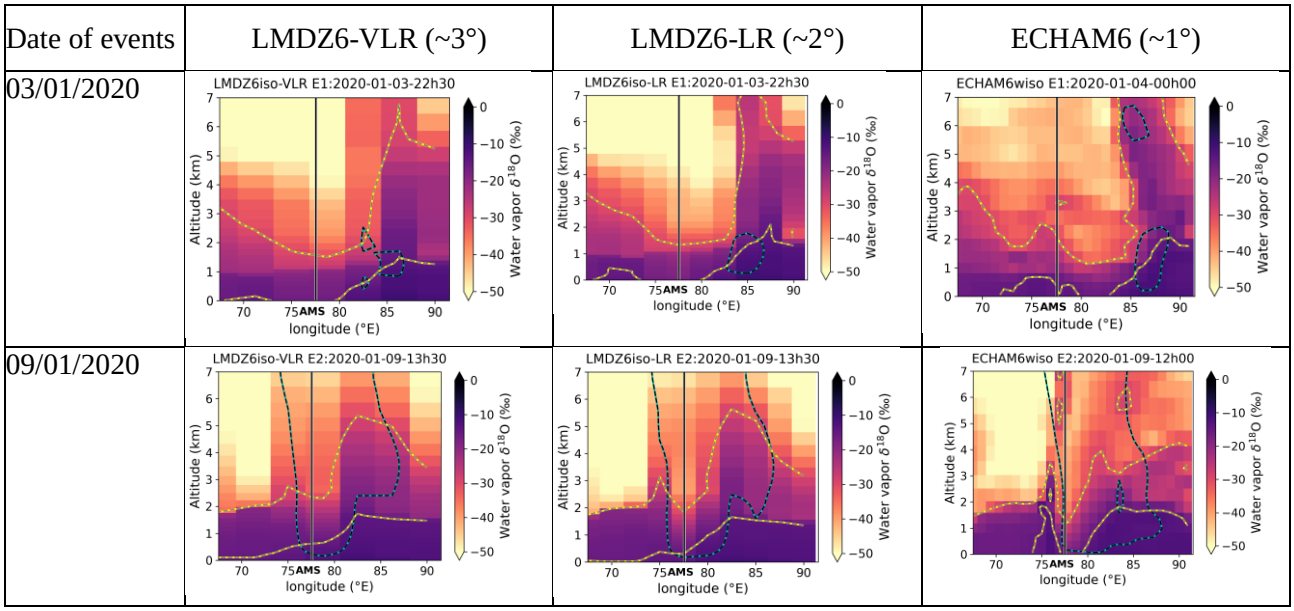
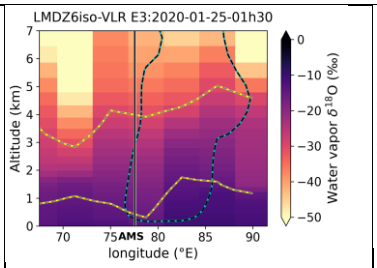
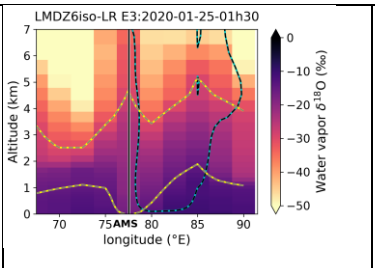
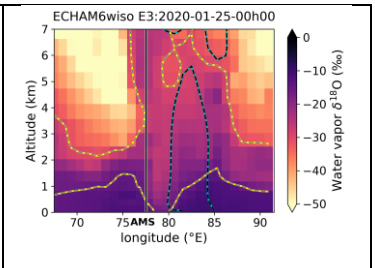
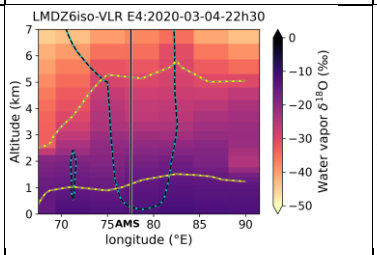
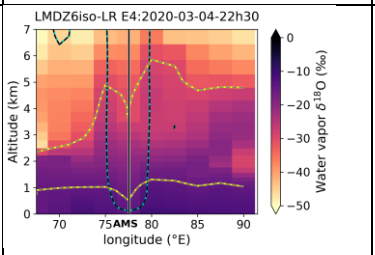
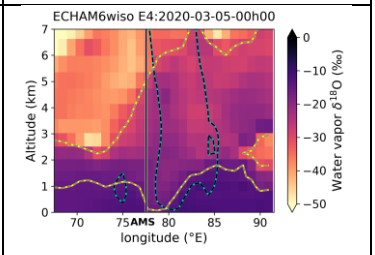
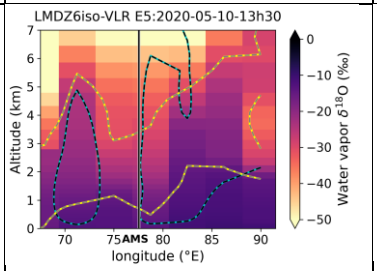
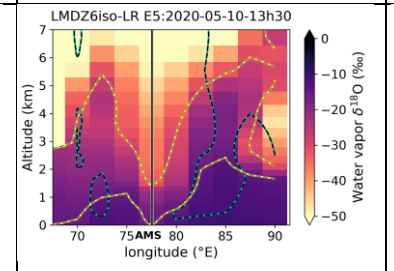
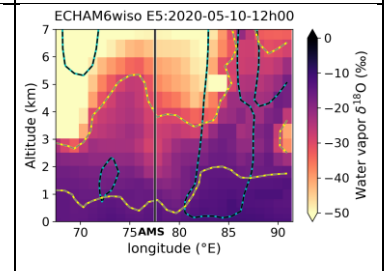
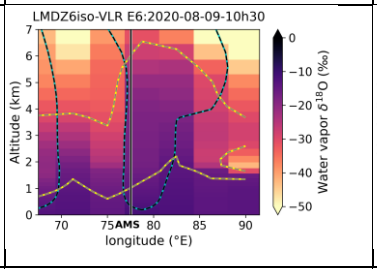
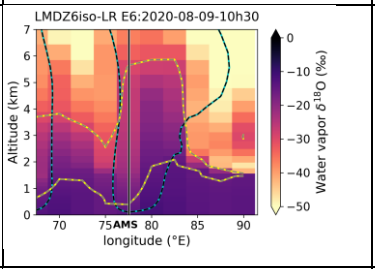
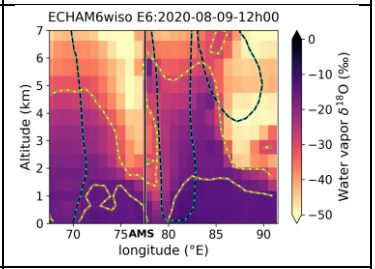
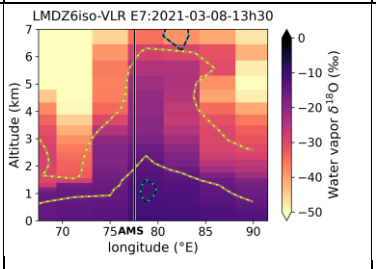
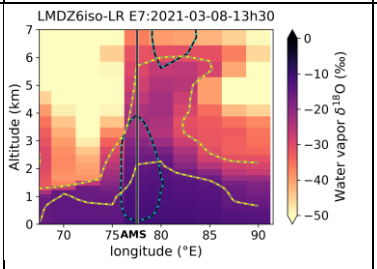
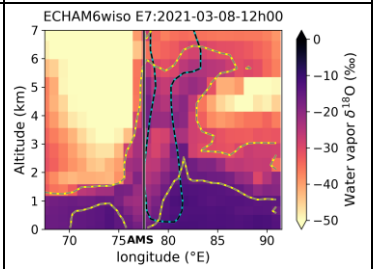
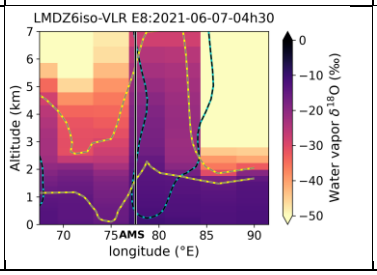
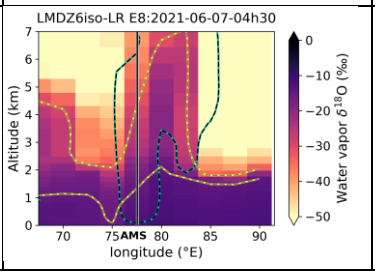
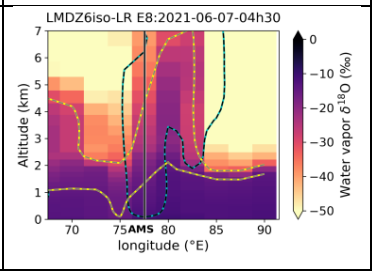


Figure S1: Synoptic analysis using hourly ERA5 fields at the time of observed minimum δ^{18}Ov corresponding to the 11 events identified in the manuscript: (a) air temperature at 850 hPa, (b) precipitation, and (c) vertical velocity at 850 hPa. White and black lines represent frontal passage, located at the maximum gradient of 850 hPa potential temperature. Front is computed as the zero-line of the gradient of the magnitude of the gradient of 850 hPa air temperature, when the gradient of 850 hPa air temperature is greater than 2 K/100 km, following Schemm et al. (2015). The black dotted line shows the transect location used for the vertical cross-section in Figure S3.



24/01/2020			
04/03/2020			
10/05/2020			
09/08/2020			
08/03/2021			
07/06/2021			

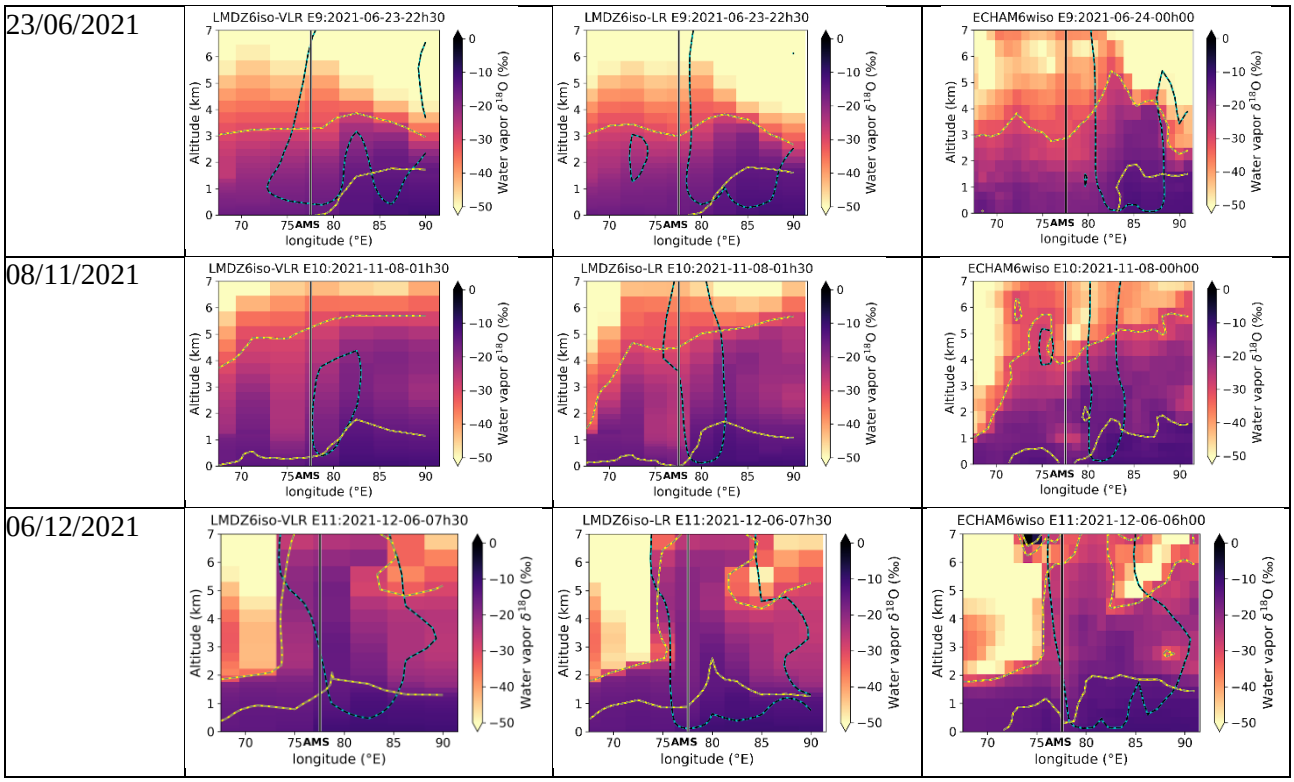
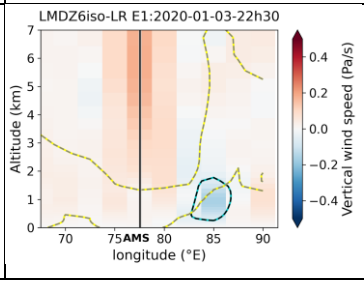
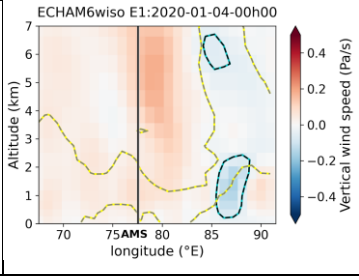
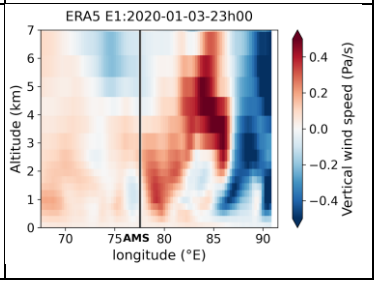
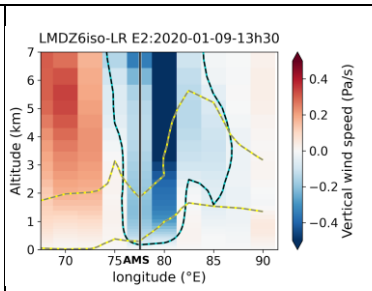
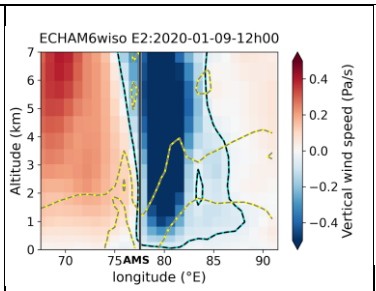
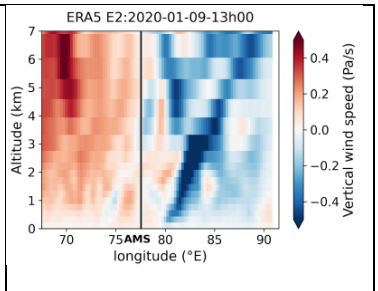
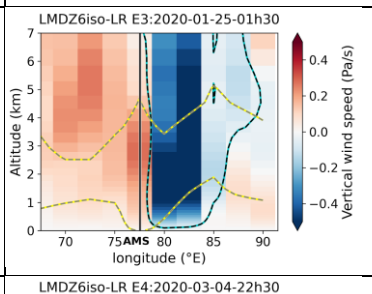
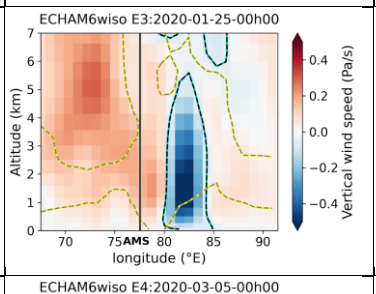
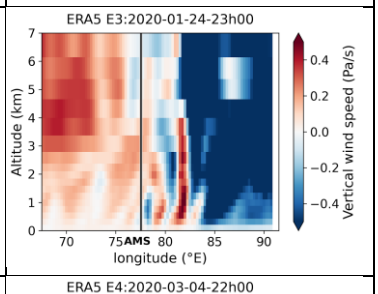
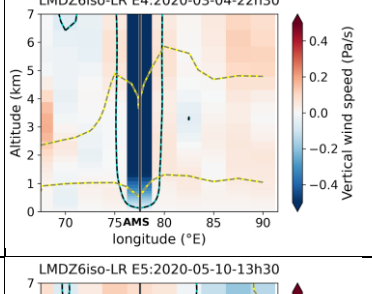
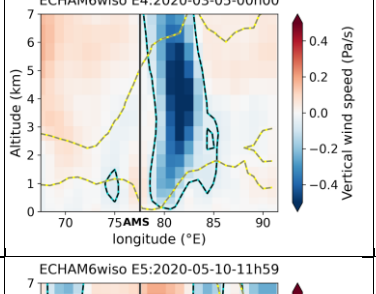
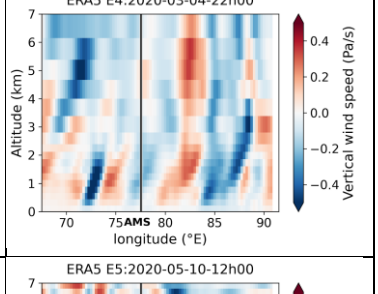
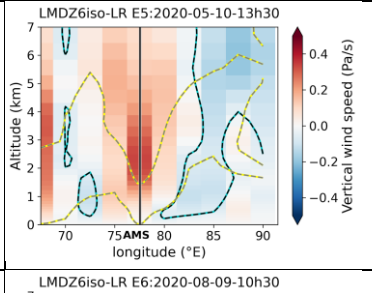
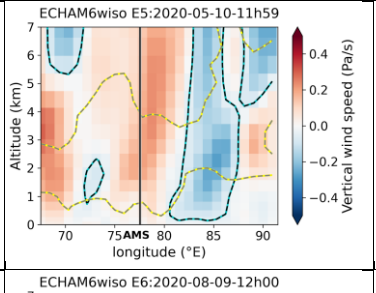
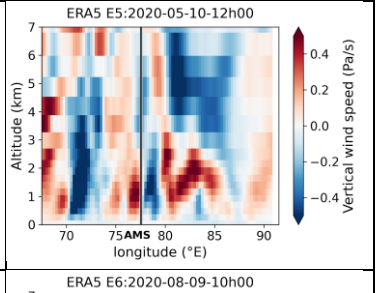
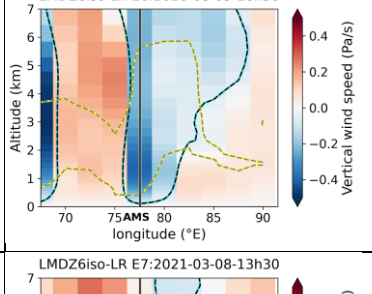
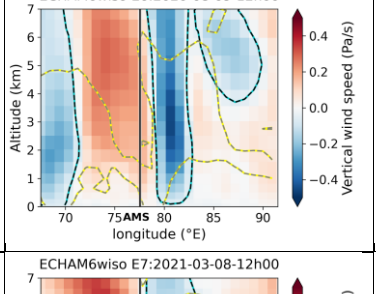
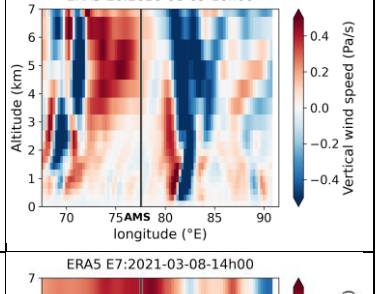
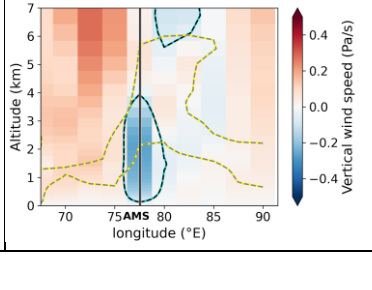
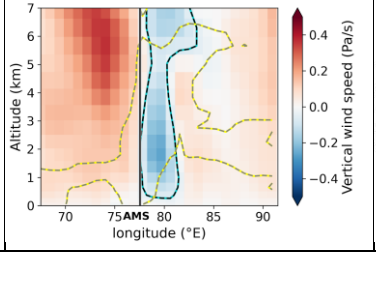
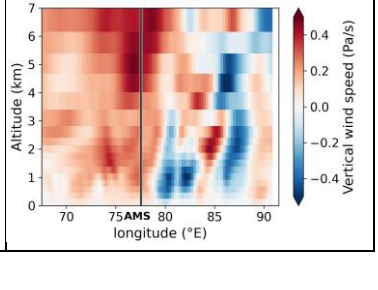


Figure S2: $\delta^{18}Ov$ plotted on a vertical cross-section (altitude vs. longitude) as modeled by LMDZ6 at very low resolution (left), low resolution (middle) and ECHAM6-wiso (right). Location of the extracted transects are indicated by the white line in Fig. 8a) for ECHAM6wiso, 8d) for LMDZ6iso-LR and 8g) for LMDZ6iso-VLR. Yellow contours indicate –30‰ (upper) and –15‰ (lower) contours of surface $\delta^{18}O_v$. Black contours indicate contours of –0.05 Pa s^{-1} vertical velocity (ascendance). The vertical black line denotes Amsterdam Island latitude.

Date of events	LMDZ6-LR (~2°)	ECHAM6 (~1°)	ERA5 (~0.25°)
03/01/2020			

09/01/2020			
24/01/2020			
04/03/2020			
10/05/2020			
09/08/2020			
08/03/2021			

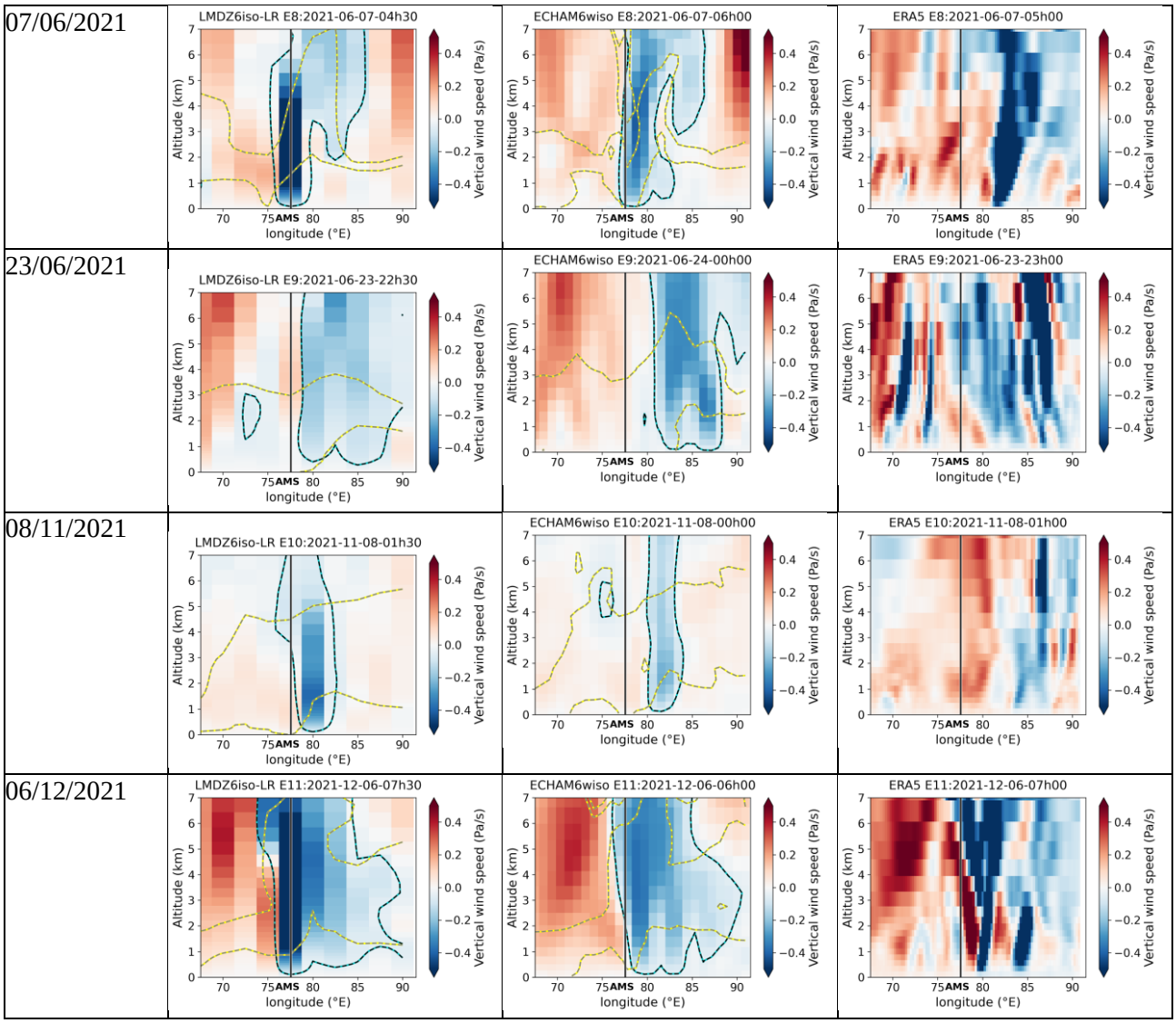


Figure S3: Vertical velocity plotted on a cross section of longitude (x) versus altitude (y) at the Amsterdam latitude as modeled by LMDZ-iso at low resolution (1st column), ECHAM6-wiso (2nd column) and ERA5 (3rd column). Location of the extracted transects are indicated by the white line in Fig. 8d for LMDZ6iso-LR, Fig. 8a for ECHAM6wiso and Fig. 8j or S1 for ERA5. Yellow contours indicate –30‰ (upper) and –15‰ (lower) contours of surface $\delta^{18}O_v$. Black contours indicate contours of –0.05 Pa s^{-1} vertical velocity (ascendance). The vertical black line denotes Amsterdam Island latitude.

Some detailed comments on this issue in the following:

why is is LMDZiso-VLR only reproducing d18O excursion on 3 Jan, what is special about this event?

The reason for that is probably that this event is associated with a strong subsidence, stronger than for other events (see Figure 5).

Figure R6: Thanks for this analysis! In front of and during event seem to be in a very similar dynamic environment (ascent; both during precipitation?) and show a similar evolution in Fig R6a. While after event shows a very different evolution. So, could this mean that during event is an enhanced signal of the before event at the rear of the precipitation event?

Many thanks for this comment. We agree with this interpretation that, during the event, we see an enhanced signal of the situation before the event at the rear of the precipitation event. However, it is difficult to go further without additional tools, such as water isotope tagging analyses. We thus prefer not speculating more on this in the article.

The locations where you chose before, during and after event in Fig. R6 are within 10° around AMS. Why do you show a 50° (or 60°) window for Fig. 8, 9, S2 and S3 if the relevant processes occur within these 10°? This aspect is mentioned again for several of the following points.

We agree and we have modified all figures accordingly.

Lines 573-575: “However, we note that when negative d18Ov excursions are not concomitant with subsidence, they occur right after an ascending movement and are generally followed by subsidence (Figures A1 and A2).”
What does “after” and “generally followed” mean? It seems that this is no longer referring to the trajectory calculations. Does this mean that large-scale subsidence (as represented by the trajectories) is not important?

Indeed, this paragraph is based on the ERA5 vertical velocity as mentioned at the beginning of the paragraph. We have rephrased the sentence to make it more clear:

« However, we note that when negative $\delta^{18}O_v$ excursions are not concomitant with subsidence, they occur at the end of an ascending movement which is generally followed by subsidence (Figures A1 and A2). »

Lines 601-604: “While the LMDZ-iso modelled vertical velocity displays a rather strong homogeneity on the vertical axis, ECHAM6-wiso modelled vertical velocity highlights subsidence of air below the ascending column at the exact location of the negative d18Ov anomaly (Figure 8c).”
Which subsidence below the ascending column do you mean? Do you mean the strong subsidence behind the cold front between 65-75°E? This does not correspond with a d18Ov excursion at the surface. The x-axis scale makes it difficult to see these small feature at the AMS location.

We agree it was not clear, we wanted to highlight subsidence between 75°E and 77°E, just below the ascending column. We made a zoom on Fig. 8 and we changed the text to clarify this.

“ While the LMDZ-iso modelled vertical velocity displays a rather strong homogeneity on the vertical axis, ECHAM6-wiso modelled vertical velocity highlights subsidence of air below the ascending column, with the maximum of negative $\delta^{18}O_v$ anomaly at the surface located just at the limit between ascendance and subsidence (between 75°E and 77°E in Figure 8c)”

Lines 605-609: “The fact that subsidence of air occurs just below uplifted air, at the limit between ascendance and subsidence (Figure 8j and Supplementary Material Figure S4), permits to reconcile the GEM data suggesting subsidence and the sign of the vertical velocity of the ERA5 reanalyses at Amsterdam Island.”
I don’t understand this sentence. What do you mean with “permits to reconcile”?

The sentence has been rewritten as follow to clarify this point:
« The fact that subsidence of air occurs just below uplifted air, at the limit between ascendance and subsidence (Figure 8j and Supplementary Material Figure S2), permits to reconcile the GEM data suggesting subsidence and the sign of the vertical velocity of the ERA5 reanalyses at Amsterdam Island suggesting that many excursions start with ascendance. »

Lines 621-623: “This ascending column is coupled to the subsidence of d18Ov depleted air at the rear of the event, which is pushed toward Amsterdam Island through a south west advection of cold air.”
What do mean with “coupled”? I don’t understand what you mean with subsidence and south west advection. Do you refer to large-scale advection within the cold sector? Is the horizontal advection an important process for the d18Ov excursions? This has not been mentioned so far. Also, the trajectory analysis did not show any important signals from large-scale advection for the selected events.

We wanted to highlight that cold fronts are usually moving from south west to north east. Cold fronts are associated with ascendance in front of the front, and subsidence at the rear of the front. We changed the text to clarify this point:

« This ascending column is generally associated with a cold front moving from South-West to North-Est (Figure 8j and Supplementary Material S1), with subsidence and $\delta^{18}O_v$ depleted air at the rear of the front (Figure 8 and Supplementary Material S2 and S3) »

Fig. 8
◦ The cold front appears as a vertical line due to the large longitudinal window. Therefore, no typical features along the cold front can be seen.

We agree, it has been fixed.

◦ Isentropes in Fig.8 could help to see the cold front in vertical profiles
We decided not to add additional lines in this figure for clarity issues, but instead we performed all vertical cross sections in the South-West to North-East direction, generally orthogonal to the front direction, for a better visualization of the front features.

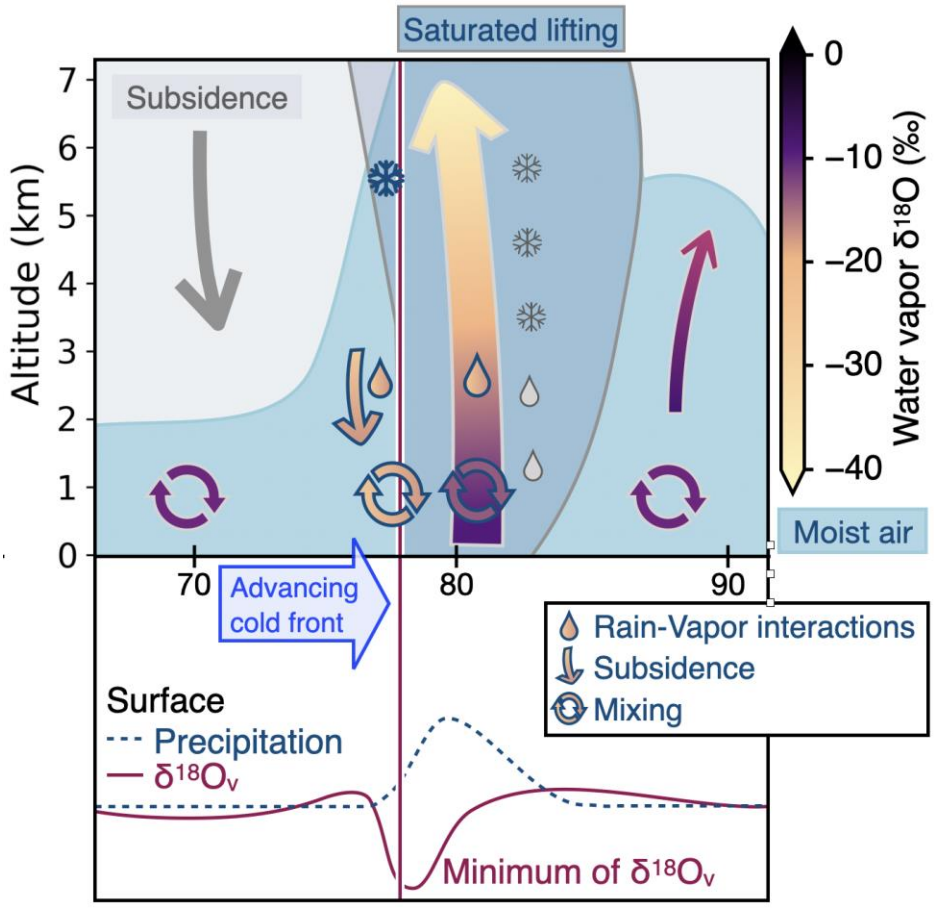
◦ Why is subsidence > 10° away from the front important for the isotopic signature during front passage? The surface isotopic composition between 60 and 75° in Fig. 8 b,e,h shows a distinctly higher signal than the water vapour above ~2km and at the AMS position. Is it important to show this to understand the processes leading to the d18Ov excursions? I recommend to choose a smaller window around the cold front for Fig.8.

We agree that the vertical structure of $\delta^{18}O_v$ just around Amsterdam is more important that the broader window initially shown, so we reduced the window to a +-10° window around Amsterdam island. The depletion is also marked at higher altitude than at the surface in ECHAM6wiso on Fig8, but it is variable depending of the events, so we decided not to comment on that in the article.

Fig.9 does not help to understand the described processes leading to the d18Ov excursion. New phrases are mentioned (e.g moist and dry subsidence, marine boundary layer) but they were not introduced in the manuscript in the context of the d18Ov excursions. It is not evident from the manuscript why processes more than 10° away from the front are important for d18Ov excursion.

You are right, we removed notions that are not introduced in the manuscript and were related to previous versions of the text. We zoomed the figure closer to the event as suggested, which indeed enables a more focused view on the depletion event at the surface. This scheme aims at summarizing many information from cross-sections into a synthetic figure, we hope it will help the reader better understand the link between water isotopes and vertical structure of the atmosphere.

You will find the updated Figure 9 below.



Minor comments:

• Lines 597/598 state “For the other events, neither LMDZ-iso nor ECHAM6-wiso show a clear signal of subsidence neither at 500 nor at 850 hPa (Figures 4 and A1).”

Neither captions of Fig 4 nor A1 state at which level the vertical velocity is shown.

Many thanks for noting this. Indeed, we simplified these figures following the comments of the previous round of reviews. So we removed now reference to Figures 4 and A1.

582-586: “Still, the fact that at least ECHAM6-wiso is able to reproduce every negative d18Ov excursion (whether they are associated or not with subsidence or rain- water vapor reequilibration) shows that not only the patterns of atmospheric water cycle are correctly reproduced (a validation which can also be performed using humidity and precipitation data) but also that the isotopic processes are correctly implemented in this model.”

Not all aspect of the atmospheric water cycle can be assessed with humidity and precipitation data only, e.g. the residence time of water in the atmosphere cannot be seen with a precipitation field, but can be traced with isotopes. This is one of the strength of an isotope measurements and isotope-enabled models.

We modified the sentence as:

« Still, the fact that at least ECHAM6-wiso is able to reproduce every negative $\delta^{18}O_v$ excursion (whether they are associated or not with subsidence or rain-water vapor reequilibration) shows that (1) the patterns of atmospheric water cycle are correctly reproduced, a validation which can be performed using humidity and precipitation data for some aspects but benefits from water isotopes implementation for the residence time of water and (2) the isotopic processes are correctly implemented in this model. »

Lines 659-660: “They are most of the time characterized by a decrease in water vapor mixing ratio. “ There is an increase in qv during the d18Ov excursions in Fig.4

There should be a misunderstanding since there is clearly a long term decrease of qv during the excursions, qv is lower after the excursion than before in Figure 4.
We propose the modified sentence:

« They are most of the time occurring during a decrease in water vapor mixing ratio. »

Lines 673-674: “This study highlights the added value of combining different data from an atmospheric observatory to understand the dynamics of the atmospheric circulation.”
This is a very broad statement? Can you be more specific what you highlight about “the dynamics of the atmospheric circulation”?

>> We propose to be more specific with this modified sentence:

« This study highlights the added value of combining different data from a surface atmospheric observatory to understand the dynamics of the atmospheric circulation, e.g. subsidence in the higher atmosphere. »

Lines 675-677: “We have especially shown that the isotopic composition of water vapor measured at the surface is a powerful tool to identify aspects to be improved in the atmospheric component of the Earth system models. “
Which aspect of the atmospheric component of Earth System models should be improved according to this study? I would say that different model setups have been used but the atmospheric component of the models stayed the same.

We have modified the sentence to better reflect the results of our work:

« We have especially shown that the isotopic composition of water vapor measured at the surface is a powerful tool to test the vertical dynamic of atmospheric models and the implementation of water isotopes for those that are equipped with them**.** »

Please, check again the chronological order of the references in the text.

The chronological order of references have been checked

Fig. S4: check caption.

Indeed, the qv plot has been removed. The caption has been changed to:

« Figure S4: Surface signal ($\delta^{18}O_v$ on the top and precipitation on the bottom) as modeled by LMDZ-iso with very low resolution (left), low resolution (middle) and ECHAM6-wiso (right). »

Answer to editor comments:

Many thanks for these comments, there are addressed as detailed below.

P5, L115: "in the mid-latitude of the south Indian Ocean" -> please rephrase

>> This has been corrected as « at mid-latitude in the south Indian Ocean »

P5, L128: "for evaluation of to evaluate atmospheric components...." -> check sentence and correct

>> We removed « to evaluate »

P6, L155: change "Magand" to "from O. Mangand"

>>Done

P6, L155: correct parenthesis around reference of Angot et al.

>> Done

P7, L191: "In this study, and even if ....." -> please rephrase to improve readability

>> We replace « if » by « though »

P7, L193: add "air" after "upper troposphere"

>> Done

P7, L194: also here, add "air" after "marine boundary layer"

>> Done

P8, L214: Check sentence, somthing is missing here.

>> Rewritten as
« The identification of such observational processes (lower concentration of GEM in high-altitude air masses compared to those in the marine boundary layer ones) is used here to help

characterize possible intrusions of high-altitude air masses at the low altitude Pointe Benedicte observatory. »

P8, L220: I would suggest to put the text part following after "and" in an extra sentence for better readability.

>> Done

P9, L236: add here to where the instrument where send.

>> Done « to Amsterdam Island »

P13, L297-298: density probability -> vice versa? Probability density?

>> Changed

P12, L314: Is the doubling of "surface" correct here?

>> Indeed, we can remove one – done.

P12, L334: Move reference at the end of the sentence.

>> Done

P13, L35: one "the" obsolete.

>> Done

P18, L475: One full stop obsolete.

>> Done

P18, L476: we indicate this "-0" -> this is indicated in the table as "-0"

>>Done

P20, L502. was taken with -> rather "calculated with" or "has a"?
>> Changed to : « has a »

P21, L516: Sentence not clear, please check.
>> Changed to
« Although the evolution of the water vapor $\delta^{18}O_v$ vs q_v is rather abrupt, there is a certain resemblance with the idealized theoretical remoistening curve initially calculated for the free troposphere (Noone, 2012) and adapted here with initial conditions corresponding to the isotopic composition of surface water vapor. »

P21, L528: Such -> This
>> done

P27, L664: With high resolution less events were reproduced? Didn't you state before the opposite?

>> I think that it is what we state – we reproduce only 1 event at very low resolution and 7 at low resolution (the « low » resolution model has a highest resolution than the « very low » one as described in the methods).

P32, L717: Do you mean with "a" panel (a)? Then you should write "(a)" instead of just "a".

>> Changed.