First and foremost, we want to express our sincere gratitude to the reviewer for their thorough review and the time dedicated to our article. Many of the comments provided are exceptionally valuable, and we acknowledge that various aspects of the paper required enhancement. The insightful feedback from the reviewer has significantly improved the paper. We address each of the comments below. For minor comments, unless specified otherwise, we have incorporated the reviewer's suggestions.

Major comments:

As you state in your abstract: “These findings highlight the importance of CAOs and the Gulf Stream region with their intense coupling between the ocean and atmosphere for block development and provide a mechanistic pathway linking air-sea interactions in the lower troposphere and the upper-level flow.”

And in the introduction: “We investigate the potential connections between air-sea interactions over the Gulf Stream region and the formation of an upper-level ridge over western Europe using a Lagrangian perspective in a synoptic analysis.”

These are the most important things shown by your work and you should not deviate from these statements (e.g., discussing dry intrusions or the PV discussion in the appendix). I have suggested several places to remove text to help keep the focus on your aims, which will also make the paper much more concise.

We thank the reviewer for their advice on how to better keep the main focus on the dynamic link between air-sea interaction and blocking over Europe. We have followed most of the suggestions and hope to even better streamline the storyline, as detailed in the answers to the specific comments below. However, we have not fully removed some of the side tracks. This is because these are aspects which we received a lot of interest from the community when presenting the work on workshops and conferences. We still think with the corrections made these statements are not distracting from the main focus.

My largest major concern, however, is around Figs 9 and 10. The figures are good, but they are not focussed on the main synoptic systems you describe in the text up to that point (i.e., L1 and L2). If they were re-produced for those cyclones, then I think the paper would read very well.

Thank you for the hint. Initially, we selected the time steps and cyclones shown, which best illustrate the general characteristics of the “handover mechanism”. However, we agree that it will be easier if cyclones L1 and L2 are shown and changed the figures accordingly.

Again, I thoroughly commend the authors for their revisions so far and I am very supportive of this work being published once the major concerns have been addressed.

Major comments:

Lines 172-175, Figure 2: Your segregation into “inflow”, “ascent” and “outflow” is confusing here, and is not truly reflective of what is going on. Parcels below 800 hPa (i.e., nearer to the surface) are not just “inflow” parcels. They are either undergoing modification or forming the inflow. Given that the inflow is only happening at the domain boundary (i.e., across the 800 hPa surface), most of the parcels will be undergoing “modification” rather than forming the inflow. I suggest you change the naming to “modification” layer as this is more reflective of what is going on (and what you are interested in). You can state that these air parcels would be in the boundary layer, over the Gulf Stream, and therefore have the potential to be modified by the high SSTs in that region. You can then refer to the 800 – 400 hPa layer as the “inflow and ascent” layer. Using the Binder et al. (2020) paper as justification for your level choices is fine, but I think using “modification” for the lowest layer is much better language and fits in better with all your arguments. You do not have to use the same language Binder et al. (2020) as your study is focussing on something else (you can just state, “called the inflow layer in Binder et al. (2020)”). Binder et al. (2020) were looking at warm conveyor belts, whereas the modification of air parcels before entering the warm conveyor belt is important here so using different wording is fully justified.

In summary: I would change 172 – 175 and state:
“An advantage of using the trajectory analysis is that we can identify where the NPVA trajectories are at different times throughout the February 2019 blocking event. The position of the air parcels can be grouped into different layers in a similar manner to that employed by Binder et al. (2020). The layers are defined here as:
1. The modification layer ($p \geq 800$ hPa, called the “inflow” layer in Binder et al., 2020) where parcels are being modified by the underlying ocean.
2. The inflow and ascent layer ($800 \leq p \leq 400$ hPa) where parcels are flowing in to the WCB and then undergoing ascent.
3. The outflow layer ($p \leq 400$ hPa) where parcels stop rising and diverge near to the tropopause.
The layers will help to elucidate the location and transfer of air parcels that are important to the February block development and maintenance. “
At the moment lines 172 – 175 appear to just be “tagged onto the end of a section” whereas stating how/what/why you are doing it clearly (in a similar way to above) means the description of Fig. 2 in section 3 makes a lot more sense. I really liked Fig. 2, once I’d worked out what was going on.

We thank the reviewer for their insightful comment and understand the perspective from which it was offered. However, after careful consideration, we have decided to continue using the established terms 'inflow', 'ascent', and 'outflow'. Our decision to adhere to these well-established terms is informed by their widespread acceptance and use in studies on ascending airstreams, e.g. Binder et al. 2020, Schäfler et al. 2014, Pickl et al. 2023, and Quinting et al. 2022 and others. We consider air streams that ascend from the lower to the upper troposphere with a pressure difference of at least 500 hPa. A substantial fraction of these air streams

fulfilled the criteria of warm conveyor belts which were the focus of earlier work on midlatitude ascending air streams. As the mechanisms facilitating ascent, latent heat release, and diabatic outflow are essential, we think it is justified to adopt previous terminology for our analysis of airstreams interacting with the Gulf Stream and ascending to the upper level NPVA. We believe that introducing new terms in place of these familiar ones could lead to confusion within the scientific community rather than aiding clarity in our paper. Regarding the 800 ≤ p ≤ 400 hPa layer, we respectfully disagree with the suggestion to label it as an 'inflow and ascent' layer. Our results, as clearly demonstrated in Figure 4, indicate that the pressure drop below 800 hPa is associated with a rapid moisture loss, indicative of ascent rather than inflow. Recognizing the importance of clarity, we have included additional explanations in our manuscript to elucidate this distinction more effectively and to better explain what we mean with the inflow layer. Also we now explicitly state that air mass modification occurs in the inflow layer and later the air converges into the ascent. These textual changes have been made in lines 170-180 as suggested.

L222 – 224: Following on from above, you state:
“On 18 February, the NPVA GS trajectories were found to be in their ascent phase, distinctly spread over the western North Atlantic, as shown by the red crosses in Fig.2a. Yet, the bulk of air parcels that later ascend into the blocking region remained in the lower troposphere. These air parcels were predominantly observed in regions influenced by CAOs in the western and central parts of the North Atlantic…”

The wording is confusing here because it draws you towards thinking that all the air parcels are associated with the CAO, which they’re not (and you don’t say they are). This is where using the word “modification” could really help. How about changing the wording to:
“On 18 February, the NPVA GS trajectories were found to be in their ascent phase, distinctly spread over the western North Atlantic, as shown by the red crosses in Fig.2a. Yet, the bulk of air parcels that later ascend into the blocking region remained in the modification layer in the lower troposphere (p ≥ 800 hPa). These air parcels were predominantly observed in regions influenced by CAOs in the western and central parts of the North Atlantic (green crosses Fig. 2b)…”

In line with our previous response, we have chosen to retain the current naming convention for the layers. However, in response to the reviewer's comment, we have clarified in our manuscript that these air masses are distinctly influenced by the processes at the ocean-atmosphere interface (lines 235-240).

Section 3.2: This section is really interesting, and you have made a fantastic effort to revise it. I’m also happy with your arguments overall. What would make this section much better would be to write the text in the order that the figures are written. You currently describe Fig 4a, then 4e, then 4f, then 4c and 4d, which leads the text to read in a disordered way. Either adjust your figure order or re-order the text to follow the figures in sequence. This will make it much easier to

read. Your arguments are good here, but the non-sequential ordering of the text and figures hides it somewhat.

We are grateful to the reviewer for their insightful feedback. In response, we have corrected both the figure (Fig. 4) and the corresponding text to better align the text and figure.

L314-325: The DI paragraph is unnecessary. You do not state this as something you are going to look at in either the abstract or introduction. The paragraph does not fit in with the focus of the paper and unnecessarily lengthens it. While this could be an interesting line of research to follow (as you say), it adds nothing to this paper and only detracts from the already good hypotheses and evidence presented.

We fully appreciate the reviewer's concerns regarding this paragraph. However, after careful consideration, we have decided to retain the short paragraph in question. We believe this section offers valuable information to the scientific community, a perspective supported by discussions at various scientific meetings and recent publications e.g. Demirdjian et. al.2023. The link between DI, CAO, and DH along the trajectories has captured the interest of researchers during our presentations of the case study results at conferences. Therefore, we feel that its inclusion adds value to our study, and at the same time doesn't create much confusion. We now clearly state that this paragraph is a sidetrack (lines 330-340).

Figs 9 and 10 and the end of Section 3.3 (L416 to L459): After all the great description of the processes happening around L1 and L2 in the preceding text, why have you decided to plot a new set of lows (l0, l1, l2) with only a passing reference to L1 in Figure 10? Furthermore, you state in the introduction (L85-86), "This event brought record-breaking winter "heat" to Western Europe and was accompanied by a series of upstream, rapidly intensifying cyclones." Moreover, you also state at L370 that "…NPVA GS air parcels coincide with the period when cyclones L1 and L2 are present in the North Atlantic…". You have shown that cyclones L1 and L2 are very important so the focus should be (and stay) on the rapidly intensifying L1 and L2 cyclones. If this analysis had been performed on the L1 – L2 sequence, then it would have supported the rest of the arguments in the paper. I find the choice here very confusing. If the focus of your paper had been the sequence of lows plotted in Figs. 9 and 10 then it would make sense here, but that is not the case. You need to either re-write everything before Section 3.3 (and the introduction) and focus on the events you plot in Figures 9 and 10 (I don't recommend this, but it is an option) or change Figures 9 and 10 to look at what happens around L1 and L2 (recommended). I can imagine the L1 – L2 (and beyond) sequence of events would also show the same processes you plot in Figures 9 and 10.

We concur with the reviewer's suggestion regarding this matter. We had chosen the initial time step to more effectively illustrate the mechanism of moisture uptake in 'recirculating trajectories'. However, upon reflection and considering the reviewer's input, we recognize the importance of focusing on the L1 and L2

cyclones. This approach aligns more closely with the trajectory analysis we have presented throughout the article. Therefore, we have updated the paragraph in Section 3.3 and moved the previously used figure to the Appendix. We chose to keep this figure in the Appendix because it clearly shows the recirculation in some of the case study trajectories. We think that these changes will improve the clarity and usefulness of the section, and we look forward to the reviewer's feedback on these modifications.

L471-490 and Fig 11: I like this schematic and description, but it needs to reflect the changes I've suggested for Figs 9 and 10 (which is why I have put it in the major revisions section). If Fig 11 is re-made to focus on L1 and L2 and lines 471-490 re-worded to reflect the changes to Fig 11 then I think this will work very well.

Following the same rationale as in our response to the previous comment, we have decided to incorporate the reviewer's suggestion, as we agree that it integrates well with the analysis presented in our paper.

Minor points:

Line 6: Change "responsible for" to "contributing to" as you show their contribution to the block, not their responsibility for it.
Line 20: Change "for blocking" to "contributing to blocking" – again, you don't show that the coupling causes blocking rather that it contributes to the blocking event.
L24: Change to "… associated surface high-pressure system…"
L47-49: Remove the sentence beginning "The air masses that undergo…" as this implies that all air masses must go through this process, which is not necessarily true. It is just one of the processes that air masses can undergo to gain moisture before ascending. This is a case study, and not "all events" are considered, therefore what might be true in this case might not be true always.
L63: Change "can regulate cyclone formation and strength" to "are important for cyclone development" – maybe they can regulate formation and strength, but I think you're more concerned with their importance, which is why I've suggested the word change.
L77: Change "ascent" to "ascend".
L107: remove "the" before "sea level pressure".
L133-136: Move to L215 – see comment for L215-218 below.
Comment addressed below.
L159: Better description now, but this is still ambiguous – "equidistant grid points of size 100x100 km." Do you mean "the domain of the grid points is 100 x 100 km" or "each grid point is 100 km away from each of its neighbours"? I'm guessing the second option; in which case it is probably better to say "equidistant grid points with a separation of 100 km between each point".
L171: Remove the words "and their subsets (NPVA GS and NPVA nonGS)" as you haven't defined these yet (I have suggested another edit below to account for this change).
L178: Change, "…over the Gulf Stream in the lower troposphere. We define the…"" to "…over the Gulf Stream in the lower troposphere (NPVA GS, see Table

1). To identify the NPVA GS trajectories, we…".
L184-187: Remove "In the following, we refer to those trajectories as 'NPVA GS trajectories (Tab 1)" and move the next sentence up to join the paragraph that finishes on L184. Start L187 by saying, "The NPVA GS and NPVA nonGS trajectories are split into their inflow, ascent and outflow stages (as described in Section 2.2.1). For each trajectory within the NPVA GS…".
L215-218: Remove these lines up to "…upper-troposphere NPVA" and replace it with the words between L133 – 136, which provide much better introductory sentences.

We acknowledge and understand the rationale behind the reviewer's suggestion concerning the paragraph's structure. However, after thoughtful consideration, we have chosen to keep its original format. Our concern is that the integration of text from lines L133-136 into the existing paragraph, as suggested, might lead to confusion. The paragraph beginning at line 215 is centered on the NPVA over the North Atlantic, and introducing information about the NPVA's lifecycle at this point could disrupt the focus. Therefore, we believe that maintaining the current structure of the paragraph ensures a clearer and more effective communication of the intended information.

L222: Remove "distinctly".
L226: Change "very intensive" to "very intense".
L225-226: "Those CAOs occurred behind the very intense cyclone L0 (Fig 3a)…" – really? The cyclone near Canada in the Labrador Sea seems to be a much more likely candidate for causing this CAO. Even the analysis in Fig 3a seems to place L0 too far to the east to cause the CAO. Please check this.
We appreciate the reviewer's feedback and have made the necessary edits to the text as suggested, mentioning the low-pressure system over Labrador Sea.

L233: Change from l1.1 and l1.2 to L1.1 and L1.2 (i.e. upper case). The ".1" and ".2" are sufficient for showing these are supplementary lows. Using the lower case "l" makes it look like 11.1 and 11.2.
L233: "The transit of this cyclone…" which cyclone? You mention L1, L1.1 and L1.2 so you need to be clear which one you mean (I assume it is L1).

L239-240: Remove the sentence starting, "The green crosses in 2f…".
We value the reviewer's suggestion; however, we do not understand the rationale behind the idea of removing those sentences. We believe they provide the necessary context, making it easier for readers to follow the text and what is depicted in the figure.

L241-242: Remove the sentence starting, "This structure not only…"
Similarly to our response to the previous comment, we are uncertain about the reasoning for the suggested removal of these sentences. After careful consideration, we have chosen to retain them in the text.
L242-243: You state that "… the L2 cyclone propagated into the region of high surface fluxes…" but you do not show it. As the cyclone propagates, it would displace the coldest air around the cyclone on its northern flank and draw up the

heavily modified former CAO (now warm sector) air over the region. The way you have worded it, it reads like you're saying the cyclone would propagate over the CAO, whereas the region would be subject to deformation around the cyclone. More likely is that the cyclone propagates on the boundary between the residual cold air from the CAO and the warmer, heavily modified air to the south. If you keep this statement then you need to show it happening, or I suggest removing this sentence.

We appreciate the reviewer's suggestion and understand the reasoning behind it. However, after careful consideration of the reviewer's comments, we opted to revise the sentence rather than remove it. This decision is informed by further analysis, enhanced by the reviewer's feedback, which reveals that the moisture sources for trajectories ascending with cyclone L2 predominantly originate from regions impacted by those CAOs. Additionally, this characteristic behavior of the cyclone aligns with the findings presented in the research works by Papritz et al. 2021 and Dacre et al. 2019, which are frequently referenced in our study. The sentence now reads: *It is important to highlight the fact as cyclone L2 propagated, it traveled into the region where the air in the lower troposphere has been heavily modified due to the surface fluxes that occurred in the wake of cyclone L1.*

L247: Remove "predominantly".
L249-251: Remove sentences starting, "Unlike cyclones L1 and L2… and black crosses in Fig 2g." There is a lot of conjecture here and it detracts from the results you are describing.
L254-258: Remove these lines as you don't look at these cyclones in any detail (apart from maybe Figs 9 and 10, but I don't think you should use these cyclones to produce Figs 9 and 10 – see major points).
Addressing two comments above: We appreciate the reviewer's perspective on this matter. However, we respectfully maintain a different view. As cyclones L3 and L4 are prominently featured in our figures, we believe it is essential to mention and provide explanations for them in the text to ensure clarity and completeness of our study.

L285: I think it should say, "within a 48-hour interval".
L291: Start a new paragraph here.
L306: change "an interplay between the block and preceding cyclones" to "the air transport through the preceding cyclones has influenced the block." There is no "interplay" as the cyclones affect the block but the block does not impact the cyclones as they have already gone by that point.
L313: Remove reference to Appendix A (due to removal of Appendix A).
L314-325: Just re-iterating to remove these lines as they do not contribute to this work nor support its conclusions.
This comment has been addressed in the response to Reviewer's major comments.
L338: No need for brackets around the Sodemann et al. reference.
L341-345: Suggest re-wording to the following so it focuses on the contents of the table:
"First, we will focus on the timing and spatial distribution of moisture uptakes of the

trajectories. NPVA GS trajectories, on average, accumulate moisture around 3.5 days before their ascent (Tab.3) with the most significant portion (60%) acquired in the first five days. In comparison, NPVA nonGS trajectories start collecting moisture about 3.8 days prior to ascent (Tab.3), with 48% of uptakes taking place within the first five days."

L355-356: Remove "the majority of the moisture originates from regions relatively close to the block (Fig. 3e). In particular" so that the sentence reads (and gets directly to the important point):

"Our moisture source identification methodology indicates that 80-90% of the uptakes…"

L365: change "when the cold" to "when cold".

L370: Remove "and L2" from the sentence. The reason for this is that L2 forms when the SLHF is very high i.e., it is high because of the CAO following L1 and L2 has nothing to do with that CAO at the time you're looking at.

L380: Start a new paragraph after "NPVA.", which should then continue as the same paragraph through L383.

L394-395: Change "Cyclone L2 traverses and strengthens within the region marked by a strong CAO left in the wake of L1 (Fig.2b and d)). This moisture-rich air potentially gets" to "Cyclone L2, traverses to the north of this heavily modified, moisture-rich air that then gets". The way it is currently worded, it reads like the cyclone propagates into the CAO, which is very unlikely given the CAO will have lost a lot of its signature. More likely is the increase in baroclinicity between the heavily modified air and the residual CAO acts as the boundary along which the cyclone propagates. My point here also applies to the point I made about L242-243 i.e., why not just show L2 propagating through the region around ~60W and we can see where the residual CAO, modified CAO and low centre are in relation to each other?

As suggested by the reviewer, we have updated the text accordingly. Moreover, as shown in Fig. 3, cyclone L2 moves into the region around ~60 W. This is further illustrated in Figs. 9 and 10, where it's evident that the moisture uptakes for trajectories ascending with this cyclone occur within the region previously affected by CAO, induced by cyclone L1. We acknowledge that this aspect may not have been clearly articulated in the original text, and have therefore made necessary modifications (lines 410 - 415). These revisions are intended to present the information more clearly, and we trust that they now effectively address the reviewer's concerns in a more comprehensive manner.

L402: "exemplary trajectory discussed before" – which example is this? Why not just say "NPVA GS trajectories"? I even think you could remove this sentence entirely without any impact on the paper.

We appreciate the reviewer's insightful comment and recognize that certain elements of our initial presentation might not have been sufficiently clear. To address this, we wish to emphasize that our analysis encompasses all time steps of the case study, available in the Supplementary Material. In the main text, we illustrate this analysis through a single example from a specific time step. This example is chosen to clearly show how the trajectories' ascent and moisture

uptake are affected by cyclones L1 and L2. We have made revisions to the text to ensure this information is conveyed more clearly and effectively.

L407-415: These can be removed along with Figure 8 as they don't add anything to the paper. You have plenty of other good descriptions of the processes and this figure and explanation are not needed. It will make the paper more concise.

We respectfully differ in opinion from the reviewer regarding Fig. 8. We believe that it offers support for the prevalence of the hand over mechanism in NPVA GS trajectories. Additionally, we are concerned that omitting these statistics might prompt questions from readers about the distribution of time differences between the ascent and uptake phases. We value the reviewer's perspective and have carefully considered this aspect in formulating our response.

L464: "disproportional role" – I don't think you have shown this. You show evidence of their involvement, not the proportion of the blocking circulation that they are contributing to. You would likely need to do some sort of PV surgery method to show the roles of the different air parcels from GS and nonGS sources. I do not think such PV surgery is necessary in your paper, however as you show GS trajectories clearly do make it into the block all you need to say is "we show evidence that they have a role in maintaining or enhancing…".
We edit the text according to reviewer's suggestions.
L417: Remove "often".
L471: change "… one cyclone ascends…" to "one cyclone can ascend…" – this is a case study and so you don't show this always happening.
L475: Change "The most robust…" to "The largest…"
L504-505: "Therefore, for the air masses that ascend into the block during the extratropical cyclones of February 2019 in the North Atlantic, these distant moisture sources seem less influential" – even though these air masses contribute most to the NPVA region? You are overstating what you show here. The paragraph reads well up to this point and is consistent with your main results. You should remove the sentence above.
L520-523: Remove the sentence starting "Consequently, we hypothesize…" – you don't discuss the termination stage and so this statement leaves me thinking "how do you know this?". You either need to show it (not recommended) or remove it. The paper does not need this statement about the decay stage as it is not the focus.

We value the reviewer's insights and have chosen to act on their recommendation by omitting the specified sentence.

L527: Change "significance of CAOs" to "significance of the modification of CAOs" – it is the modified CAO air that contributes to the block. It is no longer "cold air" nor an "outbreak" by the time it starts to ascend. The air must be modified to do this, which you paper clearly shows. Just stick with describing what you have shown.
End of the conclusions: Your future work sounds very interesting!

Appendix A: Please remove this. It doesn’t add to your analysis and makes the paper longer. You have a lot of excellent analysis that clearly show all the relevant processes. This section does not fit in with what you’ve written and makes the paper longer than it needs to be.

We recognize the reviewer's concerns about including this Appendix and understand their viewpoint regarding its potential lack of necessity. While we agree that its content may not be critical for the main body of the article, we have chosen to keep it in the Appendix. This decision is based on its relevance to ongoing research, of which we are aware, being conducted by other groups. Additionally, the topic has sparked numerous discussions during the preparation of our article, leading us to anticipate that these results are expected to be published. Placing this analysis in the Appendix seems the most suitable approach, as it allows us to share this important information without disrupting the main text's structure and focus.