Second Point by Point Response for Manuscript, entitled 'Dorff, H. et al. 2023: Observability of Moisture Transport Divergence in Arctic Atmospheric Rivers by Dropsondes', for final publication

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I) Response and Changes to the Comments from Anonymous Referee 1 (AC1)

Preface:

We thank again the associating editor, Geraint Vaughan, as well as the Anonymous Referee #1, for the secondary detailed and helpful review. Please find below our responses (in standard font) to the remarks from the Anonymous Referee #1 (in *italics*). Our changes/ modifications in the manuscript are specified **bold**. Line numbers of reviewer comments (grey) are now referred to the lines in the second revised manuscript (**black, bold**).

Erratum:

In the budget contributions (in mm per day) from Sect 4 on, we divided by the gravity at two places, causing our very low values. New values were checked many times for correctness and agree more with literature. Verification with ERA5-fields of ∇IVT showed plausible values. We now provide the values in mm/h, which is more representative for the local time scales at which they contribute. Given this circumvent, we checked all our routines for correctness several times.

Specific responses to AC1:

*reconsidered after **major revisions***
This is my second review of the manuscript by Dorff et al. Still, I think that the content of the paper is worth for publication and I want to acknowledge the authors for addressing many of my comments. The revision made the motivation and contribution of the paper better understandable and the revised structure improved the readability. Especially, the introduction and conclusion improved substantially. However, this work would profit from a clearer writing and communication of the results.
Response: First of all, we are very grateful for acknowledging the improvement of the manuscript and its consideration for publication. Given your feedback, we put more focus on communicating the results in a more concise way. Your remarks significantly helped out us to improve the readability in the second revision. For all your comments you will find our corresponding responses below, structured in the way our sections are organised.

Introduction:

L25 Change "high" to "strong"
Response/Modification: Changed correspondingly.

L30 what is "this"? "Extracted" means originating?
Response/Modification (L30f): in agreement to AC2, we reformulated to: **"For the required moisture of ARs impacting the Arctic, the North Atlantic to the south is a dominant uptake zone (Vazquez et al., 2018)."**

L34: specify what you mean with "air mass transformations" with respect to T, q etc.
Response/Modification: see comment AC2, we meant e.g. the thermodynamic vertical structure.

L37-39 these two sentences about IVT divergence do not fit here. Before and after IVT distribution is discussed. L38: "links (…) induction" - makes no sense to me

Response: Given both comments, we reformulated the phrases. **Modification (L36ff): "To illuminate moisture transformation processes occurring in arctic ARs, it is crucial to grasp spatial characteristics of the moisture transport, i.e. the vertically integrated water vapour transport. For instance, Seager et al. (2013) point out that the divergence of IVT links the local temporal development of moisture amount with the efficiency of precipitation formation. When we thus target to derive IVT divergence in arctic ARs, a prerequisite is to resolve the spatial variability of IVT."**

L42 Rephrase "widely seen"

Response/Modification (L41ff): we have rephrased as: **"Along such lateral cross-sections through the AR centre, airborne observations in mid-latitude ARs have shown a bell-shaped IVT distribution, having the strongest moisture transport in the AR core [..]."**

L43 What does "this" refer to? What is a "heterogenous spatial variability"? Heterogenous distribution of IVT or high spatial variability would be clear.

Response/Modification (L44): changed to the latter suggestion.

L44 Define "arctic AR conditions", L45 Rephrase "reflects to" – do you mean "influences"?

Response/Modification (L44ff): Here, we meant to state that the conditions omnipresent in arctic ARs are unclear, so that we reformulated:**" For the conditions in arctic ARs containing weaker moisture transport than in the mid-latitudes, […] and how this influences IVT divergence."**

L46 delete "variability"

Response/Modification (L47ff): changed according to AC2 to: **"High-resolution observations of IVT variability are not available for arctic ARs."**

L50 What does "Similarily" refer to?

Response/Modifications (L51): Changed to **"Based on a similar principle,"**

L52 I think you cannot use "subject allows to verb" in English, it needs to be "subject allows object to verb"

Response/Modification (L53): changed to **"allow derivation of"**

L60: "with" should be "of"

Response/Modification: Done

L62-63 "Deteriorations of the representation…" and "The sondes may misinterpret…" are complicated sentences. Try to formulate in a clearer way that the IVT determined from a discrete number of sondes measured along a research flight may differ from instantaneous values on the high resolution reanalysis grid"

Response: We reformulated L62-63 to be more precisely. However, we want to focus on the sonde measurement principle and find it slightly distracting to already refer to the reanalysis here. We look for the sonde-based deviations to the truth, and just use the reanalysis as a benchmark for this.

Modification (L63ff): "A limited number of sondes can cause deviations in the airborne representation of AR moisture transport variability if the sounding spacing becomes

too coarse to reflect the spatial variability of IVT. Such deviations in IVT variability come with misinterpretation of the IVT divergence."

L65: What does "an agreement up to 3% for airborne results" mean?
Response/Modifications (L67)*: We removed "for airborne results".*

L66: "Contrasting…" The sentence does not fit here.
Response/Modifications (L67ff): We rephrased the sentence to: **"Accurate airborne estimates of TIVT, juxtaposed for two separate AR cross-section legs, then provide an initial estimate of IVT divergence in between both legs."**

L69: Would be good to know the spacing in Ralph et al.
Response/Modifications (L69): Both, Ralph et al. (2017) and Guan et al (2018) refer to the same observations. Thus, we added: **"Enlarging the aforementioned sonde spacing".**

L74: Makes no sense – "but"?
Response/Modification (L75ff): We reformulated the phrasing as: **"For instance, in a polar AR case study, Terpstra et al. (2021) identified incoherent patterns of moisture and wind forming the moisture transport pattern, that are less aligned than in mid-latitude ARs."**

L75ff Explain the "disentanglement of both quantities" and how you think it may "facilitate flight strategies"? How do you "spend more investment on the airborne representation"?
Response/Modification (L77ff): We modified the concerning paragraph as follows:
"Unravelling moisture transport into wind and moisture can improve observational strategies of airborne moisture transport divergence in arctic ARs. Especially, if the moisture transport variability (and divergence) were e.g. mainly controlled by the moisture field, supplementary remote-sensing should be involved in the airborne representation of AR moisture. For this reason, it is important to determine whether moisture and wind are aligned in AR cross-sections and to ascertain: *How correlated are moisture and winds in arctic ARs, and do coherent patterns contribute significantly to IVT (Q2)?*

L83 Specify "vertical moisture and wind domains" and "frontal gradients in divergence characteristics"
Response/Modification (L81ff)*: We have rephrased and specified the aforementioned expressions for clarity and shortened other parts of the paragraph as:*
"Knowing the spatial structure of IVT is a prerequisite for flight planning and reveals insights into the moisture transport divergence pattern in arctic AR cross-sections. Since ARs primarily occur at the interface of the cold front and warm conveyor belt in extratropical cyclones (Dacre et al., 2019), different dynamic and thermodynamic processes act on the moisture transport and its divergence across the embedded front (Cobb et al., 2021). For mid-latitude ARs, Cobb et al. (2021) found significant differences in vertical moisture and wind for different sectors across the front, which are reflected in gradients in IVT divergence before and rear the front (Guan et al., 2020). Using reanalysis data, Guan et al., (2020) specified lateral differences of moisture transport divergence across centres of ARs."

L91ff: "conducted airborne studies" I guess this can be deleted.
Response/Modification: deleted

“Such research flights” – there was no information about flights, yet. Be more specific about “interpret the discrepancies”. “between” >> “between different”. Why “In contrast”?

Response/Modification (L94ff): we reformulated the corresponding part of the paragraph as: **“Norris et al. (2020) determined IVT divergence in mid-latitude ARs from dropsondes. Their research flight allows interpreting the quantitive discrepancies of IVT divergence in ARs that Guan et al. (2020) found between different reanalyses. Norris et al. (2020) point to the large variability of IVT divergence at spatial scales of 50 km, which has implications for sonde-based sampling best practices.”**

L96: Please better explain “impaired by a time component”? I guess you want to say that the estimates derived from airborne observations cover a certain time period and as the state of the atmosphere may change with the evolving weather systems, these values may not be representative for instantaneous values which are typically derived from models.

Response/Modification (L98ff): Exactly, this is what we want to introduce with L96, as we touch upon a new field (temporal evolution). Details were already given afterwards, but we now focus on more clarity. For this, we modified both phrases as:

“[…] we hypothesise that airborne results are also impaired by the flight duration: Over the duration required to enclose an AR corridor, the state of the atmosphere changes, i.e. there is relevant temporal evolution of the AR (its life cycle and spatial displacement) that causes the sonde-based values to deviate from the instantaneous IVT divergence.”

L101: These two paragraphs could be merged

Response: We decided to keep them separated, since the following paragraph summarises how we realise our approach, i.e how we examine our research questions, while the last paragraph solely constitutes a brief outline of the manuscript.

L102: What does to “to constrain on” mean? Do you want to say that you restrict your analysis to ARs in spring?

Response/Modification (L105): Changed to **“restrict”**.

Section 2:

Section 2 better focuses on the methodical aspects. I suggest moving Sect. 2.2 (Fig. 1 and 2) and merging it with the discussion of Fig. 11 at the beginning of Sect. 3 (comment below).
(originally referred to Sect. 3), *Section 3 would profit from a joint discussion of Fig. 1, 2 and 11 at the beginning, which would ease the discussion of the remaining Figures.*
Response: We decided to keep the presentation of our AR cases (Fig. 1 and 2) in the second section, as it represents our data & method section. Furthermore, Fig. 1 is used to illustrate the flight patterns positions. Nonetheless, we took your suggestion into account and merged Fig. 1 & 2 and Fig. 11 in our manuscript, but in Section 2. We included the original Fig. 11 as Fig. 2, after introducing the AR patterns in terms of IVT and glimpse the vertical characteristics of moisture and winds. At this place, we shortened the description of Figure 11 and motivate that the case-to-case variability has to be considered in the following analysis, e.g. when interpreting the results in Sect 3.3/3.4. Afterwards, the original Fig. 2 (now Fig. 3) still suits for a precedent climatological framing of our cases that should be remembered in the following analysis. Another reason for keeping all three figures in Sect. 2 is that, in Sect. 3, we want to follow the stringent change of perspective from vertically integrated AR sonde representation (in terms of IVT) towards the decomposed variability/ coherence of wind and moisture in the vertical profiles across the AR filament.
Modifications (L182ff).: Placing the original Figure 11 as Figure 2, we inserted the following descriptive paragraphs: **"Inspecting the vertical curtains of AR cross-sections, that are based on the southern red transects in Fig. 1, the specific humidity exceeds 4 g kg^{-1} in almost every cross-section (Fig. 2). This indicates that our events are rather moist for arctic AR conditions (e.g. Viceto et al., 2022), but still much drier than mid-latitude ARs where q easily exceeds 8 g kg^{-1} (Cobb et al., 2021a). Nonetheless, Fig. 2 depicts several features that we normally know from mid-latitude ARs. For example, this comprises low-level jets (LLJs) that are strong low-level wind corridors (Ralph et al., 2004; Demirdjian et al., 2020). For the windy arctic AR events, e.g. AR3 and AR5, we detect the presence of LLJs stronger than 25 m s^{-1}. The LLJ is situated at a height of around 900 hPa, slightly lower than Cobb et al. (2021a) summarised for mid-latitude ARs. Ralph et al. (2004) and Cordeira et al. (2013) found a horizontally slanted vertical structure of moisture transport in mid-latitude AR cross-sections from dropsondes and reanalyses, where Ralph et al. (2017) verified the vertical interaction between the upper-level jet and the LLJ as dominant for the AR moisture transport. In Fig. 2, their conceptual depictions reflect mostly for AR5. Here, moist air masses residing in the cyclonic warm conveyor belt are lifted over the cold front sector. The downward intrusion of the upper-level jet on the western flank causes the slanted structure in the moisture transport.**
In other arctic ARs than AR5, we find less agreement with the conceptual AR schemes presented in Ralph et al. (2017). This yields for the vertical structure of moisture, the presence and the intensity of the LLJ which is strongly distinctive in AR1, AR3, AR5, AR7, but missing there. In some cases, e.g. AR9, the upper-level intrusion is accompanied by strong dry air subsidence that reinforces the slanting of the moisture transport pattern in the mid and lower levels. The variety of characteristics of winds, moisture, and its transport comes with the different synoptic patterns (such as troughs, ridges, smaller cyclones embedded in a meridional, but weaker flow) that cause the arctic ARs. For example, we find the slanting most effective for ARs close to Eastern Greenland (AR2) or when the backside of the embedded cyclone strongly advects the dry Greenland air masses (AR9)."

The subdivision into 2.3.1. and 2.3.2 is not needed.
Response/Modifications: We restructured Sect 2.3. Sect 2.3.1 was removed. Furthermore, we removed the short Sect. 2.3.2, but merged it with Sect 2.4 in order to keep the sonde-based perspective bundled. This caused the following renaming of the section names.
Section 2.3: Emulating flight patterns to sample ARs, Section 2.4: Divergence derived from synthetic sondes, Section 2.5: AR sectors and sonde locations

L190f […] preceded by unnecessary introductory statements about what is done next.
Response: This has been removed by merging section 2.3.1 and 2.3.2.

It should be explained more carefully how flight pattern are defined.
Response: We restructured the concerning paragraph and specified the flight pattern definitions more thoroughly as:
Modifications (Line 224ff): "We place such zigzag flight patterns over the AR corridors at the sea ice edge (Fig. 1). We orientate the cross-section legs orthogonal to the major IVT direction and extend the legs such that they transect the entire AR, as long as the AR boundaries remain over open ocean and sea ice and disregard land. We obtain the boundaries from AR catalogue of (Guan,2022). The meridional distance between both cross-sections is assured to be larger than 200 km, but closer than half the lateral AR width. The final distance is chosen individually by visual inspection, as we allow flexibility for the actual flight planning. Due to their proximity to the sea ice edge, the transects of AR corridors are mainly located north of AR centres (horizontal lines in Fig. 3)."

It should be explained more carefully how […] the simulated dropsondes are placed (Sect. 2.3). This part is confusing. For example, you describe "six" sondes, but Fig. 5 shows seven sondes. Please explain how the number was defined and how this refers to the methods.
Response (i): In the previous Sect. 2.3, we intended to only present the sonde emulation, without further specifying where actually placing the sondes. In contrast, in Sect. 2.5, the description of gradients along the AR cross-sections due to the presence of embedded cold-front structures allows for further specification on how to place the sondes in the sectors. This has been modified to be more explicit (see comments for Sect. 2.5 below). Note that in Sect. 4.1 and 4.2 the sonde placing is equidistantly, as the sector classification is less relevant when the total cross-section IVT is examined.
Response (ii): When we speak of six sondes with respect to Fig. 6, we mean three sectors from each cross-section (six in total) that a span a single sector, and this corresponds to seven sondes per cross-section.
Modifications (i): We renamed Sect 2.5 to **"AR sectors and sonde locations".**
Modifications (ii, Line 302ff): we reformulated: **"Using seven synthetic sondes per cross-section of the AR, we locate the sondes so that three sondes each in the in- and outflow cross-section span one out of three frontal sector (Fig. 6) and calculate its IVT divergence, respectively."**

The sector classification (Sect. 2.5) should be more specific. Throughout the manuscript you often talk about a "frontal classification" or "frontal sectors", although it is never described how the classes based on IVT thresholds relate to the cold front location. Additionally, the boundary between core and pre-frontal sector is not a frontal boundary.
Response (I): We specified the frontal characteristics that are omnipresent in the vicinity of the AR and further explained the expected location of the cold front. We further checked throughout the manuscript if the term "sector classification" is less misleading than "frontal".
Modification (I, 277ff): We rewrote the first paragraph as: **"Research considering IVT divergence in ARs suggests distinguishing between different sectors along the lateral**

AR cross-sections. Guan et al. (2020) highlight that different dynamics take place across the cold-frontal structures that are commonly embedded in the AR, which itself is situated at the western end of warm conveyor belts (Dacre et al., 2019). Hence, Guan et al. (2020) separate IVT divergence calculations across the major AR axis and the AR embedded front. Similarly, Cobb et al. (2021a) classified different sectors in ARs based on the position of the AR embedded cold front and IVT shape of airborne observations of a large set of pacific AR cross-sections. Both approaches distinguish between frontal sectors, namely a pre-frontal (warm) sector, the AR core with highest IVT, near which the cold front is expected (Ralph et al., 2017), and the post-frontal (cold) sector behind the cold front. Since there exist significant differences in moisture transport divergence between the sectors (Guan et al., 2020), a large part of the variability is smoothed out when calculating IVT divergence for entire cross-sections.”

Response (II): Indeed, the terms are conventions from precedent studies, and we agree that the boundaries cannot be considered as real robust frontal boundaries. However, we can be certain that our so-called pre-frontal sector mostly contains warm airmasses ahead of the front, while the post-frontal sector primarily contains colder airmasses prevailing behind the front. As already done in the first paragraph (see above), we inserted an additional clarifying statement in the second paragraph, but kept the terminologies in the remainder of the manuscript to ease readability. We agree that the explanation of the outer edges of the pre- and post-frontal sectors is misleading, as they actually focus on significant IVT that belongs to the AR.

Modifications (II, Line 290ff): For our sector classification we reformulated: **“Following Ralph et al. (2017), we expect the cold front in the vicinity of the AR core. We denote the region east of the core as the pre-frontal sector mainly containing warm airmasses and west of the core as the post-frontal sector that reaches out of the cold front in colder airmasses. Since we focus on the AR relevant regions with high IVT, we restrict the outer extents of both extra-frontal sectors. For both sectors, we assign the outer edges where IVT >0.33 IVT_{max} to account for case-specific relative values (Fig. 5).**

(Line 299ff) […] Both thresholds form the outer edges of the AR where our pre- and post-frontal AR sectors end. Note that our sector terminologies only categorise the prevailing air masses of an AR, but should not be viewed as a synoptic cold-front identification.

Figure 4 is confusing as it extends from left (east) to right (west). I wonder why you don’t not use the same case in Fig. 4 and Fig. 5.

Response/Modification: We now have chosen the same case for Fig. **5**(4) and Fig. **6**(5) and added a clarification in Fig. **5**(4) as: **“The orientation of the x-axis is in flight direction, from west to east.”**

The sondes are not equidistant and do not lie at the boundaries of the sectors (at the intermediate time). Explain!

Response/Modification: We clarified the explanations, that were too confusing before, as:
“Given the varying sector lengths, the sonde spacing is not equidistant in Fig. 6. Additionally, the comparison to the IVT contours in Fig. 6 reveals that the sondes do not lie at the sector boundaries at the intermediate timestep. Our IVT-based AR sectors, i.e. sonde positions, are defined for each airborne cross-section representation individually and thus do not refer to IVT conditions at an intermediate time step. In fact, there is a north-eastward displacement of the AR filament over the course of the 2.5 synthetic flight pattern. For this reason, the sectors along the flight track tilt while the internal IVT has a northward orientation.”

How would the placement of the sondes be considered in flight planning to cover the sectors best?

We come back to this in the conclusions where we mention concrete suggestions. Overall, as stated before when focusing on placing a sonde at the forecasted IVT maximum and placing the others symmetrically around is a simple and quite promising approach. Further specifications are out of the scope of the feasibility during flight. Given our thresholds, it is recommended to place all sondes in regions where IVT is simulated to exceed 100 $kgm^{-1}s^{-1}$.

Section 3

L287-291 […] preceded by unnecessary introductory statements about what is done next.

Response: We agree that the paragraph was overloaded with outlining statements. We carefully revised this part, but still placed some overarching statements, that, to our opinion, ease the logical order and readability of the remaining section. We link each of our research questions Q_i to the corresponding Section. Given the recommendations by AC2, we remind for the large case-to case variability of ARs, and we state again that CARRA represents our truth in which we mimic the soundings.

Modification (Line 312ff): We reformulated as: **"To examine the moisture transport variability in arctic ARs, we follow a two-fold approach. First, we stick to the plane perspective and determine the maximum distance between sondes needed to derive the total IVT in AR cross-sections accurately (Q1). The synthetic soundings assess the observability of AR moisture transport by discrete sondes. Since we lack real observations, we declare the AR representation in CARRA as our truth. Second, we analyse to what extent coherent patterns in moisture and wind speed anomalies contribute to moisture transport and its variability (Q2). It is crucial to link the results to the large case-to-case variability with respect to IVT magnitude (Fig. 1) and the vertical moisture and wind fields (Fig. 2)."**

would profit from a joint discussion of Fig. 1, 2 and 11 at the beginning, which would ease the discussion of the remaining Figures.

Response: The shift to Sect. 2.3 of Fig 11 already helped to merge the discussion. At the beginning of Sect 3, we will only place a short reference back to the case-to-case variability. The detailed linking to the remaining Figures of Sect 3 and, in particular, Sect 3.3 and 3.4 are still drawn in the corresponding sections. Thus, we remained at inserting the statements shown in our precedent answer.

In Sect. 3.2 the lengthy and complicated introduction of Fig. 7 (L322-335) should be shortened. The comparison to different thresholds is not revealing and impairs the description of Fig. 7.

Response: We have removed too much details in the first comparison referring to AR1. Furthermore, we have shortened the second paragraph in its introduction of Fig. 7 and focused on the key messages (relevant sonde spacing) earlier.

Modifications (L347ff): First two paragraphs:**" The accuracy in sonde-based TIVT of an AR cross-section depends on the number of sondes across the AR, i.e. their spacing (Ralph et al., 2017). Larger spacing of sondes affects the derived moisture transport variability, whereby the sonde location becomes increasingly relevant. For example, the equidistant placing of six sondes within AR1, as shown in Fig. 7, underestimates TIVT by roughly 10 % against the continuous IVT representation. For all of our ARs, we assess the sounding spacing, needed to gain adequate TIVT estimates, by varying the density of synthetic sondes and by comparing their TIVT values with those of the continuous AR cross-section representation in CARRA. To account for the dependency on sounding location, we conduct a bootstrapping approach in which we sample the cross-sections with varying release spacings and varying sounding locations, from which we derive TIVT. From this, the grey box-whiskers in Fig. 8, showing the distribution of sonde-based errors of TIVT, reveal that the relative error of TIVT against the continuous AR representation increases significantly for sounding spacing ≥ 150 km. This corresponds to roughly five sondes for the given cross-section lengths, and release intervals above 10 min at a cruising speed of 250 m s^{-1}). For sonde spacing ≥ 200 km, sonde-based TIVT can substantially deviate."**

I do not understand the analysis of moisture variability in Sect. 3.3 extending into the post-frontal cold sector where dry descending air is located (Fig. 11). This certainly doesn't characterize the relative role of q and winds for variability of strong moisture transport in the AR (L385).

Response: We checked that less than 10% of our cross-section lengths reach out of the AR edges. Our cross-sections are aligned to the AR shapes defined in the AR catalogue of Guan et al. 2022, that refers to vertically integrated IVT thresholding, representing the most common AR classification. There may occur coexisting air masses along the vertical profile. Accordingly, in AR domains, there can exist substantial dry descending air above, while the moisture transport underneath is still designated as AR. If we neglected these regions, we would also neglect large cross-section parts being designated as AR from the IVT perspective. Therefore, we argue that our inclusion of the vertical columns with dry air intrusions are valid.

Modification (Figure 2, caption): To achieve clarity for the reader in advance, we added the AR pattern based on the AR catalogue of Guan et al. (2022) in Figure 1 and referred to it in the caption of Figure 2 as: **"As visible in Fig. 1, some ends of the cross-sections already reach out of the ARs, but this constitutes less than 10% of the cross-section lengths."**

Consider shortening the discussion about orographic effects at Svalbard, which seems not to be relevant.

Response/Modifications (L383ff): We shortened this part as follows **"However, the winds in our AR cross-sections (Fig. 9a) are roughly twice as strong as given in their case study, which reports an orographic deceleration by Svalbard. For our arctic ARs, the open ocean enables stronger winds, rather comparable to the wind conditions in the mid-latitude ARs.**

Are "coherence" and "coherent" and "non-coherent" transport established terminologies in this context? I wonder why the transport driven by small scale fluctuation is named coherent?

Response/Modifications: Yes, these terms are established to emphasise that the small-scale fluctuations of wind and humidity must be correlated. Random fluctuations cannot generate a flux. Only coherent anomalies or patterns of these variables lead to moisture transport.

Moving Fig. 11 at the beginning of Sect. 3 would ease the interpretation in Sect. 3.4. The discussion is rather long and repeats things that were already discussed (e.g. ~L370).

Response: The discussion in Sect 3.4 now has shorten, as some text parts introducing the AR curtains are now listed in Sect 2.2. Consequently, we have several cross-references to the original Fig. 11 (now Fig. 2) to interpret our results.

Modification (L436ff): See for example: **"Apart from AR5, other ARs exhibit less coherent patterns where wind and moisture do not necessarily correlate with each other (see also Fig. 2). Valid for most of the ARs, the correlation between moisture and wind peaks in the LLJ height. The negative correlation in Fig. 11 refers to AR9 that indicates a clear horizontal displacement of the wind and moisture fields (Fig. 2). Here, subsiding dry air masses in the cold sector counteract the westward increase of wind speeds.**

Summarizing Fig.10 and Fig. 11, the moisture variability mainly steers the moisture transport variability above the marine boundary layer. This shows analogously in more horizontal overlap between fields of moisture and moisture transport as against the wind fields (Fig. 2). Especially, AR1 and AR3 exhibit small horizontal variability in the wind field, as winds are almost constant along the entire cross-section (> 25 m s−1). The ARs, being variable in moisture, consist of an elevated moist plume only residing in the AR core that is surrounded by dry air."

Why is the strength of the subsidence determining the slanting (L442)?

Response: We actually intend to connect the zone of dry subsidence with the tilt of the moisture transport. We see the slanting of the moisture transport mostly overlapping with the moisture gradients, resulting from the dry air subsidence caused by the cold front. However, our connection was imprecise. It was thus deleted, as described appropriately in the modifications above.

How do you know about the distribution of warm conveyor belt air, a concept which was not introduced or used before?

Response: As specified in our responses for Sect 2, we now introduced the warm conveyor belt location with respect to the AR location and refer to Dacre et al. (2019). For our knowledge of the distribution of warm conveyor belt air, we visually inspected reanalysis-based Theta-E charts at 850 hPa to identify its general region. In the manuscript, we do not specify this identification for brevity and easy readability, as we would then distract more from the AR analysis.

Section 4:

L463-467 a lot of introduction.

Response/Modifications (L462ff): We agree that there are many introductory sentences, but due to the amount of assumptions and methods used, some of which change between the sections, we want to ensure clarity for the reader as how the following results have to be treated. Nonetheless, we rephrased the section introduction and reduced the outline of all steps, in order to focus more on the connection to the precedent section. For this, we also moved the last statements of Sect 3, as follows:

"The incoherent cross-section patterns of moisture and wind fields (Sect. 3) suggest lateral differences in the moisture transport divergence components (Eq. 5), and motivate investigating the divergence in separate sectors across the front embedded in the AR. Showing the limits in TIVT-based divergence, we investigate whether high moisture advection occurs more frequently in strong moisture-dominated AR sectors and whether mass convergence dominates in windy AR sectors. By categorising our results based on the AR sectors (Sect. 2.5), we examine how the divergence of moisture transport is characterised along cross-sections of arctic ARs (Q3), and evaluate how the sondes reproduce the features of the continuous cross-section representation."

"Idealising (…) takes place" - I cannot find where in Sect. 3 you showed details about fluxes across the eastern and western boundaries. It would be good to know how valid this assumption is. How do these results agree with findings from the other approach?

Response (I): We had an erroneous section reference included. We specified that we meant (Sect. 2.4), in which we, in the first paragraph, describe the simplification of IVT divergence by contrasting out- and inflow TIVT, assuming that no flux across the boundaries takes place. We further slightly modified the corresponding sentence in Sect 2.4:

Modifications (I, L): "Neglecting the moisture flux apart from perpendicular to the flight track, i.e missing fluxes across the eastern and western boundaries, we can approximate ∇IVT in an AR corridor by the difference of out- minus ingoing TIVT of the cross-sections."

Modifications (II, L477): By contrasting the in- and outflow cross-section legs (Fig.12), it can be estimated whether convergence or divergence of moisture transport inside the AR corridor exists, under the idealisation that no lateral entrainment into the AR corridor occurs (Sect. 2.4).

Response (II): It is especially the confluence of post-frontal air masses that is responsible for considerable deviations of the TIVT- based moisture transport divergence against the regression-based divergence (see Sect 4.2). The arctic ARs show significant entrainment through the western boundaries. Moreover, IVT is only an integrated quantity, and thus also of the mean wind direction. In our case, we do also not separate between zonal or meridional IVT_x or IVT_y.

Modification: In restructuring Sect. 4.1, we put more focus on argueing why TIVT-based divergence is not promising.

L495-501 a lot of details:

Response/Modifications (L493ff): When deleting the introductory phrases completely, we perceive the explanations of the following results as too unclear, since the reader is not aware of the all included observation perspectives/assumptions. Instead, we shortened the paragraph as:

"To derive the IVT divergence (∇IVT), we thus use the regression-based approach (Sect. 2.4) for moisture advection ADV and mass convergence CONV. The results from the

continuous cross-sections are compared to results based on the synthetic sondes that sample the cross-sections (as illustrated in Fig. 6).”

The exemplary case study (Fig. 13) and the average integrated values (Fig. 14) could better connected.

Response/Modifications (L537ff): We improved the connection between both figures, and referred back to Figure 13 in a dedicated paragraph: **“The overall pre-frontal moisture advection in Fig. 14 is aligned with the profiles of AR3 (Fig. 13). Pre-frontal moisture advection primarily occurs in the mid-levels. The mass divergence in the core is surprising as most arctic ARs contain LLJs (Fig.2), which are associated with high mass convergence in mid-latitude AR. However, the low-level mass convergence below 800 hPa, found in many of our AR cases like AR3 (Fig. 13), is often superimposed by mid- and upper-level mass divergence above the LLJ (e.g. Fig. 13), as the AR spreads out. The mass convergence in the post-frontal sector marks the highest inter-case variability. The high values of mass convergence, mostly from low-levels as in Fig. 13, mainly arise from two cases (AR3, AR7). Here, we find changes in wind direction, as visible from the surface isobars in Fig. 1, inducing the confluence of moist marine boundary layer air masses. For the sign of post-frontal advection, the effectiveness of subsidence of dry air overrunning the western AR edge in the mid-levels becomes crucial (see Fig. 2 and 13).”**

The increased moisture convergence is restricted to the marine boundary layer - why is this the case and how are the other features related to the vertical distribution of moisture transport and the synoptic situation?

Response: We briefly sketched this in the manuscript by describing that the low-level mass convergence results from confluence as also remarkable from the surface isobars in Figure 1 (see above). This becomes more effective due to the high specific humidity in the marine boundary layer, that is however less variable in the marine BL, so that moisture advection remains weaker.

You state that the negative contribution of the core region (Fig. 14) to the moisture budget is different to the extratropics and thus surprising. Can you explain what that means?

Response/Modification (L551ff): It means less favourable conditions for the formation of precipitation. Indeed, inspecting the reanalysis precipitation, we see precipitation foremost from the western half of the AR center, constrained to a narrow swath. Consequently, we inserted into the manuscript:

“Unlike the mid-latitudes, the upper-level dominating mass divergence in the core of arctic AR lowers the triggering of precipitation by convection. Instead, major precipitation fields are often shifted towards higher reaching convergence west of the IVT maximum (not shown).”

To what extent is the cold sector moisture vertically transported and producing rain?

Response: This is a very interesting question following our added argumentation of less favourable precipitation triggering in the core. Still, a robust answer requires supplementary trajectory analyses following the air masses. We consider this as out of the scope of this manuscript. Furthermore, the description of the AR IVT divergence conditions for Figure 14 is already quite detailed so that such analyses would further distract from our primary focus being the sonde-based observability / reproducibility of the moisture transport divergence.

Your question is somewhat related to the answer of the beforementioned comment, showing the western shift of the precipitation field. Nonetheless, in a follow up study comparing the moisture budget components for a specific airborne AR case, we will come back to your point, as we there find similar IVT divergence features.

Where is that mid-level mass divergence coming from? I wonder whether you can better connect these results to the case study showing the vertical distribution of the CONV and ADV?
Response/Modifications (L539ff): We added the reference to the case of AR3, where we see the same feature: **"However, the low-level mass convergence is found in many of our AR cases, but often superimposed by mid-level mass divergence above the LLJ (e.g. Fig.13), as the ARs spread out."**

"we recognize (…)" (L532) - why should the divergence be underestimated due to lower vertical resolution?
Response/Modifications (L527ff): Coarse vertical resolution may cause spatial aliasing. This become effective in lower levels where divergence shows larger amplitudes especially in terms of low-level convergence in the vicinity of the LLJ. The divergence in mid-levels exhibits more homogeneity (see Fig. 13). Accordingly, we briefly added in the manuscript: **"Thus, the rather low divergence shown in Fig. 13 is probably not only the result of true lower divergence that prevails in arctic ARs compared to mid-latitude ARs. It can also result from the coarser vertical resolution leading to spatial aliasing in narrow convergent low levels."**

L556-565: If it can't be compared I suggest skipping the whole discussion.
Response/Modifications (L561ff): The first expression was misleading, as we solely wanted to emphasize that there are numerous differences in our AR sectors compared to those of Guan et al. However, we fully see the validity for the comparison of our values with Guan et al (2020) in principle (paragraph before), since we built on their methods and derive equivalent quantities for the arctic ARs. Instead, we reformulated: **"Nonetheless, the precedent comparison of our sector-based values of moisture transport divergence in arctic ARs to those in Guan et al. (2020) has to consider additional aspects."**

Section 5:

Can you really speak of distortion or error? Isn't it just a difference related to the temporal evolution of the AR in strength and location?

Response: We agree that the term "error" is quite strong and we removed it. However, we are convinced that distortion remains a valid term, as the sonde-based results are generally used to interpret the actual divergence features in air masses. These airborne values can be distorted by the temporal evolution of the AR, causing different gradients in the AR as actually present in the AR corridor at an intermediate time step. In particular, this may cause erroneous conclusions for the analysis of air mass transformation with respect to the moisture budget components in the ARs.

Modifications (throughout): Still, we replaced the term "error" for "deviations" due to the temporal evolution, and placed "distortion" or mostly "deviation" instead (also applies for axes in Fig. 15 and 16).

Please explain carefully how you treated the sonde locations for this comparison? Do both versions use the same locations or are they relocated when using instantaneous IVT?

Response: First in Figure (15), we compare both continuous representations to neglect any sonde spacing dependencies. For our following comparison, we kept the equivalent sonde locations in order to rule out further dependencies in our final analysis. We tested the relocation of the sondes for our IVT-thresholding in both time perspectives, and the divergence values and deviations to the continuous perspective slightly change for the individual cases. However, they do not change to an extent that our conclusions need to be modified. Keeping the sonde locations fixed, we really intercompare the local effect of AR evolution on given sounding positions. This may be of higher interest for later uncertainty assessments in flight campaigns in which the sondes were already released. Accordingly, we inserted in the manuscript:

Modifications (Line 608f): "To purely attribute the non-instantaneous effect on the divergence estimates at specific sonde locations, we hold the sonde positions fixed in both time perspectives. Thus, we do not relocate the sondes, once the sector-based IVT thresholds are exceeded different locations in the instantaneous representation occur."

Why "ideal representation"? I would understand if you talk about a representation of the continuous and instantaneous IVT values by a certain number of sondes (Fig. 16).

Response: The representation, that is instantaneous and continuous, is the optimum airborne perspective for the moisture budget assessment. However, it would require an infinitely fast aircraft conducting soundings continuously and thus represents an idealization. Moreover, it would fulfil instantaneous airmass investigation for connecting the derived moisture transport divergence with local change of water vapour, precipitation and evaporation.

Modification: To ensure more intuitive readability, we now term the **"optimum airborne representation"** to ensure that our perspective remains in the observations and their ideal realisation.

Conclusions:

This section significantly improved, but could be shortened at the end. L698-710 are a lot of repetition and the purpose or difference to the preceding conclusions should be made clear.

Response: We shortened this paragraph, and merged some of its sentences with the bullet point questions above. However, although the paragraphs resemble the bullet points, their statements generalise/merge the key messages of the research questions in an overarching way for implications and recommendations for actual flight planning.

Modifications (L701ff): "The synthetic study confirms the observability of moisture transport divergence in arctic AR corridors by releasing sondes in such dedicated flight patterns. Notwithstanding that we could release more sondes, it is the temporal evolution of the AR over the flight duration that leads to higher deviations in the divergence components rather than sonde undersampling. These deviations range from 25--50% of the divergence values. Therefore, the dedicated planning of such sonde-based purposes should not only include the sonde positioning, but also the minimisation of the flight duration. The placement of cross-section legs and their spacing should carefully consider the AR displacement during flight. Shorter distances between the cross-sections not only reduce the flight duration, but also the area enclosed by sondes. Given the widths of the arctic AR sectors, both cross-sections should be no more than 200 km apart. For several of our cases, the meridional separation is higher, and we have to expect considerable subgrid scale variability. The optimal and still feasible strategy represents collocated flights by two aircraft, with both cross-sections being not far apart and sampled simultaneously. Supplementary measurements of moisture should be prioritised due to its higher variability, and its advection dominating ∇IVT.

It also should be mentioned that your conclusions are drawn from simulations and should first be verified by observations, as you do not know to what extent the small-scale variability is reproduced in the reanalysis.

Response/Modifications (L712ff): We added this very valid point at the beginning of the paragraph evaluating the limitations of our study as:

"Additional limitations of our study need to be discussed. All our conclusions, especially the described AR characteristics, are drawn from simulations and should be verified with observations, as the extent to which the simulations reproduce the small-scale variability is uncertain."

For Q4 I would like to know how the sonde placement and the number of sondes would affect the differences between the instantaneous "truth" and the simulated sonde-based approximation.

Response: We have merged Q4 with some of the statements/repetitions in L698-710 and rephrased/restructured its content in order to better address your valid expectations.

Modification (L687ff): "For reproducing IVT divergence, the undersampling by a limited number of sondes matters. We recommend a sequence of at least seven sondes per AR cross-section. Given the widths of arctic ARs, this corresponds to a maximum sonde spacing of 100 km. Symmetrically placed around the maximum IVT, three sondes per AR sector leg are capable of reproducing the sector characteristics of moisture transport divergence components with similar magnitudes. The mean absolute deviations to a continuous AR representation along the flight reach up to 0.1 mm h^{-1} (Fig. 14). However, the deviations for moisture transport divergence by undersampling are minor compared to the deviations induced by the flight duration that mostly range from 25-50% of the actual divergence values. Non-instantaneous sonde-based estimates deviate the most in the post-frontal cold sector, where we detect steeper

gradients in moisture and winds than in the pre-frontal sector. Here, the AR displacement during flight, which is not necessarily along the moisture transport direction, as well as the intensity of dry intrusions on the backside of the AR is relevant for more than twice the deviations in ADV and CONV, partly exceeding 50% of the actual values. Unlike the undersampling, non-instantaneous effects deteriorate the results more consistently. The moisture advection is overall most sensitive to the airborne sampling. In fact, the post-frontal divergence (from ADV and CONV) and the pre-frontal moisture advection are stronger than assumed by the sondes during flight. Although mass confluence is relevant in the post-frontal sector, it is overestimated by sondes

Line 731ff: "Consistently mimicking the soundings is a fundamental step towards the understanding of the uncertainties when such airborne tactics are actually carried out." The sentence is correct but very vague. It is not clear to me what "consistently mimicking" means. What is the "fundamental step towards the understanding of the uncertainties" you made – of what uncertainties? And what "airborne tactics" are you talking about?

Response/Modifications (L733ff): We intended to link the added value of our assessment for the future measurement strategies and the analysis of sonde-based results from real campaigns. Thus, we reformulated: **"Emulated soundings assess possible airborne misrepresentation in moisture transport divergence and will improve the interpretation of future real soundings interpretation of future real soundings aiming for the airborne closure of the moisture budget in ARs."**

"Only by illuminating the constraints on the AR representation from both models and observations, we establish a framework from which airborne observations can support modellers in terms of the resolution and complexity required for parameterisation of moisture transformation processes caused by IVT divergence in arctic ARs.": What means "illuminating the constraints on the AR representation from both models and observations"'? – what is your work contributing to model and observation differences? What exactly is `the "framework" that supports modellers in terms of resolution? What "parameterisation of moisture transformation processes" are you referring to?

Response/Modification (L736ff): For more clarity, we reformulated: **"With quantified limitations in the sonde-based AR representation of IVT divergence in arctic ARs, future airborne observations can better assist modellers in terms of the resolution and complexity required to represent ongoing moisture transformation processes."**

II) Response and Changes to the Comments from Anonymous Referee 2 (AC2)

Preface:

We thank again the associating editor, Geraint Vaughan, as well as the Anonymous Referee #2, for the secondary motivating and helpful review. Please find below our responses (in standard font) to the remarks from the Anonymous Referee #2 (in *italics*). Our changes/ modifications in the manuscript are specified below. Line numbers of minor comments (grey) are now referred to the lines in the second revised manuscript (**black, bold**).

Specific responses to AC2:

*accepted subject to **minor revisions***

I appreciate the authors' efforts to address the first round of suggested revisions. I think they have done a nice job providing more background and context, and clarity on the questions they are seeking to answer with this study. I have some remaining suggestions to improve on the presentation/language, and I think the writing could still be substantially improved overall. These suggestions are examples and similar edits (e.g., appropriate word choice, simplifying sentence structure) should be considered throughout. I look forward to seeing this contribution in the literature.

Response: First of all, we are very grateful for acknowledging the improvement of the manuscript and its consideration for publication. Given your feedback, we put more focus on the writing and presentation style.

Abstract:

"adequately sporadic" does this mean "adequately spaced"?
Response/Modifications (L1f): No, it was meant that "adequate" refers to the representation, but it was imprecise. We reformulated the sentence as: **"This study emulates dropsondes to elucidate the extent to which sporadic airborne sondes adequately represent divergence of moisture transport in arctic ARs."**

Line 20 – "rather" change to "also"
Response/Modification (L20): Done
Line 21 – "quantify" change to "identify"
Response/Modification (L21): Done

Introduction:

Line 30: – does this mean that the moisture is from the south? Please rephrase for clarity. Suggestion: "The North Atlantic to the south is a dominant moisture update zone for ARs affecting the Arctic"
Response: Yes, we meant this. We slightly changed your suggestion as follows:
Modifications (L30f): "For the required moisture of ARs impacting the Arctic, the North Atlantic to the south is a dominant uptake zone (Vazquez et al., 2018)."

Line 31 – does "in an interplay" mean when ARs are associated with the other features mentioned? Suggest clarifying here.
Response/Modifications (L31): Changed to **"Embedded in"**

Line 34 – suggest defining "air mass transformation" briefly even if you are reiterating how it is used in You et al. 2022.

Response/Modification (L34): We added a specification stating that is meant in the vertical structure of the atmospheric conditions: **"[…] air masses are subject to transforming thermodynamic vertical structures. "**

Line 39 – "considered" change to "used"
Response/Modification (L40): Done

Line 40 – "specify" change to "identify" or "investigate"
Response/Modification (L40): we chose **"investigate"**

Line 45 – "reflects" do you mean "influences
Response/Modification (L46): changed to **"influences"**

Line 46, suggest rephrase to "High-resolution observations of IVT variability are not available for the Arctic"
Response/Modification (L47): changed accordingly.

Line 47 – by "sporadic" do you mean infrequent here?
Response/Modification (L47): changed accordingly.

Line 52 "allow to derive" change to "allow derivation of"
Response/Modification (L53): changed accordingly.

Line 56: "The overall goal of the study is to assess the observability of moisture transport divergence in arctic ARs by dropsondes. This assessment comprises (a) The role of dropsonde frequency,(b) The influence of correlated moisture and wind fields on moisture transport, (c) Dropsonde capacity to reproduce IVT divergence in arctic ARs, (d) Impact of extended flight duration". I think this could be clarified – bullet 3 is basically the same as the overall goal. Item 2 should be clarified in terms of how that relates to the observability of moisture transport.
Response/Modifications (L57ff): We rephrased the long sentence and redefined bullet point 3 as: **"The overall goal of this study is to assess the observability of moisture transport in arctic ARs by dropsondes. The assessment targets the facilitation of measurement strategies in dedicated research flight campaigns, as e.g. proposed by Wendisch et al. (2021). It includes (a) the role of sonde frequency, (b) concretising the need for supplementary measurements based on moisture and wind variability, and c) the impact of extended flight duration under evolving AR conditions on the dropsonde capacity to reproduce IVT divergence in arctic ARs."**

Line 65 – remove "being"
Response/Modification (L66): Done

Line 94 – does this mean sonde-based sampling best practices? Or results? If results, consider clarifying what is meant.
Response/Modifications (L96f): We want to more focus on the best practices here and rephrased: **"[…] which has implications for sonde-based sampling best practices."**

Line 102 – suggest "constrain our analysis" or "focus" instead of "constrain"
Response/Modifications (L105): In accordance with AC1, we rephrased: **"restrict our analysis to"**

Section 2:

Line 155 – "principle" should be "principal"- unless you mean its observability in principle
Response/Modifications (L158): We changed to **"principal"**

Line 158 – "restrict to conditions and events" change to "selected events"
Response (L161): Done

Line 158 – not sure what "Reacts very prone" means – does it mean the sea-ice is more vulnerable somehow to the influence of ARs during this season? Consider clarifying this language.
Response/Modification (L160f): We rephrased: **"[…] when maximum sea-ice extent in the Arctic Ocean starts to break-up and is more vulnerable to the intrusion of warm and moist air (Rostosky et al., 2023)."**

Line 163 – "to be conducted" change to "to conduct".
Response (L166): Done.

Line 164 – "2020, presented in Fig. 1" change to "2020 (Fig. 1)"
Response (L167): Done.

Line 165 – remove "commonly"

Response: Done.

Line 167-168 – "we confirm a large case-to-case variability regarding the synoptic situation" "we confirm large case-to-case synoptic variability"
Response (L170): Done.

Line 201 – why can the internal line but not the cross- sections be used for precipitation rate, evaporation, or water load? Couldn't the internal line also get IVT (albeit not along a cross section)?
Response/Modification (L219ff): For sure, all legs can be used to measure all quantities (IVT, IWV, precipitation & evaporation). However, with the physical conception of a budget box (Fig. 4b), the legs have certain focusses. We thus reformulated: **"The boundary cross-section legs perpendicular to the major flow focus on quantifying the corridor in- and outflow, i.e. in- and outgoing IVT over the entire lateral AR extension and enable simplified divergence calculations. Note that the diagonal internal legs can focus on assessing precipitation rate, evaporation or water load inside the AR corridor so that this pattern allows quantifying the remaining moisture budget components of the budget box, i.e. AR corridor (Fig. 4b)."**

Include a list of things you are neglecting – e.g., dropsonde drift and perhaps a note on why investigating other limitations, e.g., the instantaneous sampling of the full cross section is more important.
Response/Modifications (L246): According to AC1, we reorganized the sections, and placed the emulation of sondes in Sect 2.4, where we more concisely listed our assumptions and focusses as: **"We synthetically refer to the measurement principle of dropsondes (Sect. 1). Along the continuous airborne AR representation of the cross-sections (Sect. 2.3), we depict profiles as synthetic soundings for which we neglect any vertical drift or fall time. We also neglect any measurement uncertainties. Such effects are out of the scope of this study, and assumed to cause lower deviations than our considered effects. Our sondes observe exact IVT values at the release position. Instead, we focus on the spatial representativeness of sporadic sonde-based IVT and evaluate the uncertainties in the**

lateral variability of moisture transport, and how these uncertainties affect the airborne non-instantaneous perspective on IVT divergence in arctic ARs."

Line 259 – not a complete sentence, rephrase, maybe "Current research considering IVT divergence in ARs suggests that it is essential to distinguish between different sectors along the lateral AR cross-sections"

Response/Modifications (L277f): changed to **"Research considering IVT divergence in ARs suggests that is essential to distinguish between different sectors along the lateral ARs cross-sections."**

Line 269/throughout – I think maybe you mean "example" rather than exemplary? Consider rephrasing for clarity.

Response/Modification (throughout): We checked our manuscript and rephrased accordingly where appropriate.

Section 3:

Section 3.1 – consider noting that this is assuming that ground-truth is as appears in the reanalysis, and perhaps note that we may learn more as we start making observations in these regions. /throughout

Response: Since this is an overarching information holding for the entire Sect 3 (and the remaining results), we placed it in the introductory part of Sect 3 where we also refer back to Fig. 1 and 2, i.e. the AR cases and their case-to-case-variability as desired by AC1.

Modification (L312ff): We reformulated: **" To examine the moisture transport variability in arctic ARs, we follow a two-fold approach. First, we stick to the plane perspective determine the maximum distance between sondes needed to derive the total IVT in AR cross-sections accurately (Q1). The synthetic soundings assess the observability of total moisture transport by discrete sondes. Since we lack real observations, we declare the AR representation in CARRA as our truth. Second, we analyse to what extent coherent patterns in moisture and wind speed anomalies contribute to moisture transport and its variability (Q2). It is crucial to link our results to the large case-to-case variability with respect to IVT magnitude (Fig. 1) and the vertical moisture and wind fields (Fig. 2), and to attribute the results to synoptic AR precursors."**

Line 301 – remove "Only"

Response/Modification: we removed the entire phrase at it is too redundant here and thus distracting.

Line 347 – suggest rephrase to "Too coarse sonde spacing enhances the likelihood that the sampling will not capture the strongest IVT" or something similar. I don't think you mean to say that you will miss the IVT overall with the transect focusing on the IVT.

Response/Modification (L365ff): We inserted: "**Too large sonde spacing enhances the likelihood that the sampling will not capture the region of strongest IVT."**

Sometimes the authors state "Arctic ARs" and other times "arctic ARs" consider being consistent with this throughout.

Response/Modification (throughout): We cross-checked the manuscript for consistency and speak of **"arctic ARs"**.

Line 389 – what are the supplementary remote sensing devices? Are they successful at getting near-surface moisture fields in the presence of precipitation? If not maybe state "the ability of supplementary remote sensing devices […] to derive moisture fields should/could be explored"

Response/Modification (L399ff): changed to: **"The identification of the more variable quantity can improve measurement strategies. Specifically, in case of a moisture dominance, the ability of supplementary remote sensing devices from the research aircraft to derive moisture fields could be explored. "**

Line 445 – do you mean causing here? Or "associated with"?

Response/Modification (L197f): This sentence has moved to Sect 2.2, introducing the AR cases and their variability. We really meant "causing", but reformulated: **"The variety of characteristics of winds, moisture, and its transport comes with the different synoptic patterns that cause the arctic ARs (troughs, ridges, smaller cyclones embedded in a meridional, but rather weak flow)."**

Section 4:

Line 478 – “narrow” change to “wide”:
Response/Modification (L474): Done.

Line 519 – not sure what you mean by “differ quietly to” – I think it should be rephrased to “differ from”
Response/Modification (L512f): Changed accordingly.

Line 522 – this full sentence is confusing, rephrase – potentially “The lack of pre-frontal moisture advection in AR3, found robustly in mid-latitude AR statistics (Guan et al., 2020), is worth mentioning.”
Response/Modification (L514f): Changed accordingly.

Line 568 – do you mean the observability, in principle? Or principal observability?
Response/Modification: We meant the latter and modified accordingly.

Conclusions:

Line 683 – "to reproduce" change to "of reproducing"
Response (L698): Done.

Line 698 – consider rephrasing to remind the reader that the dropsondes are synthetic here.
Response/Modification (L701f): we reformulated: **"The synthetic sondes confirm the observability of moisture transport divergence in arctic AR corridors by releasing real sondes in zigzag flight patterns in the future."**