Response to reviewer #1

We thank the reviewer for reading the last version of the manuscript and for his/her new technical corrections. We hope that the corrections suggested by the two referees, which are implemented in that new version, will satisfy the reviewers and convince them about the potential of the IASI HNO3 dataset.

Technical corrections

[l289: 'indicates' -> 'indicate']
[l381: 'demonstrated' -> 'demonstrate']
[l391: 'a factors' -> 'of factors']
[l455: 'represents' -> 'represent']
All the technical corrections are implemented in the new version of the manuscript.

Response to reviewer #4 – M. Santee

We deeply thank Michel Santee for her review, for reading the manuscript with attention and for her help in rewriting some unclear sentences; her corrections are clearly improving the paper. We address all her comments below on a point-by-point basis. We hope that with the corrections made in the manuscript and the clarifications given below, Michel Santee will consider that the paper can be published in ACP.

Comments

[L19: in the mid-stratosphere --> in the lower-to-mid stratosphere; also, delete "causal"]
Done

[L23: This wording is very awkward; I suggest: evolution of the pair HNO_3-temperature --> evolution of HNO_3 together with temperature]
Done

[L24: The meaning of "in the cycle of IASI" is not clear – do the authors mean "annual cycle"?]
Indeed, "annual" has been added.

[L27-28: delete "differentiating"; add "to be differentiated" after "profile"]
Done

[L28: Two different values for the average drop temperature are given in the text on p. 6 (L265 and L290). These values need to be reconciled and the correct one quoted here.]
194.2 ± 3.8 K is the drop temperature including the year 2014, while 194.1 ± 2.8 K is the drop temperature when 2014 is excluded. The year 2014 is now taken into account through the revised manuscript when mentioning the average drop temperature.

[L32-33: It is a bit of an exaggeration to say that "this paper highlights the capability of IASI to monitor the long-term evolution of polar stratospheric composition and processes involved in the depletion of stratospheric O_3". It would be more accurate to state that "this paper highlights … evolution of polar stratospheric HNO_3, a key player in the processes involved …"]

Done as suggested.

[In a number of places in the presentation of background material (e.g., L39, L42, L45, L51), a few citations are given for very well-established concepts, but many other equally suitable papers could have been cited instead of or in addition to the ones listed. Obviously not all relevant papers can be referenced for these points, but "e.g." should be added in these lines to avoid giving readers the impression that the selected references are the only appropriate ones.]
Done

[In addition, the recently published PSC review paper by Tritscher et al. (Rev. Geophys., 2021) covers all of this background material and should also be cited in several places in this section.]
We thank Michel Santee for suggesting that impressive review paper. As required, it is now cited in several places in this section.

[L44-45: Technically, denitrification delays only the reformation of $ClONO_2$ – HNO_3 is not required for HCl production, thus it is not quite correct to say "chlorine reservoirs" here.]
Changed to: "The denitrification of the polar stratosphere during winter delays the reformation of $ClONO_2$, a chlorine reservoir, and…".

[L46-47: PSCs surface --> PSC surfaces; PSCs particle --> PSC particles]
Done

[L47-48: three 3different --> three different]
Done

[L56: delete comma after "(T_{ice})"]
Done

[L60: A reference should be provided for the point that NAT nucleation was thought to require temperatures below T_{ice}.]
Zondlo et al. (2000) and Voigt et al. (2003) have been added here.

[L73: the PSCs formation --> PSC formation]
Done

[L74: add a comma after "2019)"]
Done

[L74-75: This sentence ("The influence of HNO_3 in modulating O_3 abundances in the stratosphere is furthermore underrepresented in CCMs") is out of place and potentially confusing for many readers, who will naturally assume that it has something to do with PSC processes in the lower stratosphere as it comes at the end of a long paragraph discussing nothing but PSCs. Kvissel et al. (2012), however, describe HNO_3 enhancements between 10 and 1 hPa induced by energetic particle precipitation. It's not clear why this sentence has been included here; perhaps it is meant to provide motivation for this study, but I doubt that IASI total column measurements with maximum sensitivity around 50 hPa could shed much light on modest (< 6 ppbv) HNO_3 enhancements in the middle and upper stratosphere. In fact, this issue is not explored in the manuscript. Thus this sentence should be deleted.]
The sentence has been deleted as suggested.

[L77: measure --> have measured]
Done

[L79-82: This poorly composed sentence is grammatically incorrect and hard to interpret. I'm not sure what is meant by "follow their formation mechanisms". I suggest alternative wording, but I may have misunderstood the intent: Spaceborne instruments such as the CALIOP/CALIPSO lidar and MIPAS/Envisat measuring in the infrared are capable of detecting and classifying PSC types, allowing their formation mechanisms to be investigated (Lambert et al., 2016; Pitts et al., 2018; Spang et al., 2018, and references therein); these satellite data complement in situ measurements (Voigt et al., 2005) and ground-based lidar (Snels et al., 2019).]
Corrected as suggested.

[L84: the PSCs formation --> PSC formation; Urban 55 et al. --> Urban et al.]
Done

[L86: depends --> depend]
Done

[L92: similar to the limb --> similar to that from the limb]
Done

[L94: where the PSCs cloud form --> where PSCs form]
Done

[L95: 10-years --> 10-year]
Done

[L96: for providing --> to provide]
Done

[L104: embarked on --> onboard ("embarked" is not the right word)]
Done

[L117: FWHM --> full width at half maximum (FWHM)]
Done

[Figure 1 caption:
o L446: molec.cm-2/molec.cm-2 --> molec.cm-2/molec.cm-2
o L446: after "molec.cm-2/molec.cm-2" add "; colored lines, with the altitude of each kernel represented by the colored dots)"
o L447: Height --> Heights; 169,40 --> 169.40]
Done

[L122 & 125: Height --> Heights]
Done

[L126-127: Above (in L119) it was stated that the largest sensitivity of IASI is from ~70 to ~30 hPa, and here it says "the altitude of maximum sensitivity (at around 30 hPa for this case)". This is confusing because the grey line in the Arrival Heights panel of Fig. 1 depicting the "sensitivity profile" peaks at

~75 hPa, not 30 hPa. I believe that it is the total column averaging kernel, not the "sensitivity profile", that determines the altitude of maximum sensitivity? The authors should take into consideration that not all readers of this paper will be experts on IASI data or will have read Ronsmans et al. (2016). Please clarify the meaning of the "sensitivity profile" (grey curve) and the total column averaging kernel (black curve) and how they relate to the altitude where IASI provides the most information on HNO_3.]

- The averaging kernel profile describes how the true state changes the estimate at a specific altitude, i.e. how the retrieval smooths the true profile ($d(HNO3_{ret})i/d(HNO3_{true})j$).
- The total column averaging kernel ($d(column_{ret})/d(HNO3_{true})j$), i.e. the sum of the averaging kernels, indicates how the true state at a specific altitude changes the retrieved total column, i.e. the sensitivity of the total column measurement to changes in the vertical distribution of HNO3, hence, the altitude to which the retrieved total column is mainly sensitive/representative.
- The sensitivity profile ($d(HNO3_{ret})i/d(column_{true})$), i.e. the sum of the elements of an averaging kernel characterizing the retrieval at a specific altitude, returns the sensitivity of the retrieval at that altitude, i.e. to which extent the retrieval at that specific altitude comes from the spectral measurement rather than the apriori.

The following sentence has been added in the revised version: "The total column averaging kernel (in black) indicates the sensitivity of the total column measurement to changes in the vertical distribution of HNO_3, hence, the altitude to which the retrieved total column is mainly sensitive/representative, while the sensitivity profile indicates to which extent the retrieval at one specific altitude comes from the spectral measurement rather than the a priori."

Indeed, the altitude of maximum sensitivity of the total column measurement refers to the total column averaging kernel (black curve). This is now clarified in the revised text in order to avoid confusion.

[L127: At Lauder on the contrary, --> In contrast, at Lauder]
Done

[L128: "larger range of maximum sensitivity" – again, is this conveyed by the "sensitivity profile" (grey curve) or the total column averaging kernel (black curve)?]
See our response to the comment [L126-127] here above.

[L129-130: The statement "from around 3% at … polar latitudes to 25% above the cold Antarctic surface during winter" is confusing, because of course the Antarctic is at polar latitudes. Please be more precise in the wording here.]
Corrected: "… from around 3% at mid- and polar latitudes (except above Antarctica) to 25% above cold Antarctic surface …".

[L130: DOFS --> degrees of freedom for signal (DOFS)]
Done

[L132: "lower than 12%" is ambiguous here; assuming that the values are biased low by more (not less) than 12%, this should be rewritten as "low bias (exceeding 12%)"]
Corrected to: "… and a low absolute bias (smaller than 12%)".

[L135: FTIR measurements which is not possible during --> FTIR measurements, which cannot be made during]
Done

[Figure 2 caption:
o L454: It should be explicitly stated here (not only in the text) that the MLS total column estimates were obtained by extending the MLS partial stratospheric column values using the FORLI-HNO3 a priori information.
o L454: 2.5 x 2.5 --> 2.5° × 2.5°
o L454: middle --> bottom
o L455: Figure 2 does not include a panel showing 30°–50°S EqL]
Corrected

[L137: 2.5 x 2.5 --> 2.5° × 2.5°]
Done

[L139: The meaning of "the averaging kernels … were considered" will not necessarily be clear to all readers. It would be better to state explicitly that the IASI averaging kernels were applied to the co-located MLS profiles.]
Corrected as suggested.

[L140-141: "column profiles" is an oxymoron. Please specify the MLS retrieval pressures over which the partial stratospheric column was calculated. Thus, rather than "… grids, then converted into column profiles. They were also extended down to the surface by considering the …", it would be better to rephrase along the lines of "… grids, and partial stratospheric columns above xxx hPa were calculated. MLS total columns were then estimated using the …".]
Rephrased to: "The MLS VMR profiles over the 215-1.5 hPa pressure range were first interpolated to the FORLI pressure grids and extended down to the surface by using the FORLI-HNO3 a priori profile, and then converted into partial columns."

[L155-165: In their Short Comment, Manney & Santee pointed out: "It is highly problematic to use a single theta level to distinguish inside from outside vortex regions for column measurements. This approach implicitly (and erroneously) assumes that the vortex does not tilt, shrink, or expand with height over the altitude range considered. A better approach would have been to check PV over a range of levels and discard measurements classified as outside the vortex at any one of those levels." In my opinion, the authors have not adequately addressed this point. I understand that 530 K falls in the region of the atmosphere where IASI has maximum sensitivity to HNO_3. Nevertheless, it is simply not credible that changes in the size, shape, or location of the vortex over the 30–70 hPa domain primarily covered by the measurements had no effect on the results on any day in the 10-year IASI record. At this point, I am not suggesting that the authors redo their analyses, but I would like to see added to the manuscript an explicit acknowledgment of the fact that relying on the determination of the vortex boundary on a single potential temperature surface for interpretation of total column measurements inevitably introduces some uncertainty into the results because it fails to account for the possibility of changes in the size, shape, or location of the vortex with altitude.]
In order to address this comment, we have added this paragraph in the revised section 4.1:

"Finally, it should be noted that, because the size, shape or location of the vortex vary slightly over the altitude range to which IASI is sensitive (from ~30 to ~70 hPa during the polar night), the use of a single potential temperature surface for the calculation of drop temperatures could introduce some uncertainties into the results. However, several tests suggest that these variations of the vortex are overall minor and, hence, could only have limited influence on the delimitation of the inner polar vortex (delimited by a PV value of $-10\times10^{-5}K.m^2.kg^{-1}.s^{-1}$ at 530 K) and on the detection of the average drop temperature inside that region."

[L158: closing “)” missing after “2016)” – it should be “2016))”]
Done

[L158: “starts a few degrees or slightly below” is awkward and confusing – “slightly” could mean “a few degrees”. It would be clearer to say: “starts within a few degrees below”]
Done

[L161: It is not quite correct to say “to identify the PSCs-containing regions” – regions with temperatures below the threshold do not necessarily contain PSCs. It would be better to say “to identify regions of potential PSC existence”.]
Done

[L170: delete the comma after “S)”]
Done

[L170: This wording – “over the whole period of measurements (2008–2017)” – seems to imply that IASI has taken no data since 2017, which I do not believe is the authors’ intention.]
Changed to: over the whole study period

[L172: 2018) where the contribution of the PSCs into --> 2018), where the contribution of PSCs To]
Done

[L173: delete “here”]
Done

[L175-176: The wording “along the HNO_3/temperature cycle” is not clear. I think the authors mean “within the HNO_3/temperature annual cycle”. Or maybe “during” rather than “within”]
Changed to: during the HNO_3/temperature annual cycle.

[L184: “R1 in Figures 3a and b” – since the regimes are clearly labeled in the panels of Figure 3, I’m not sure that this statement is needed. Moreover, the label “R1” is also used in Figure 3c.]
“R1 in Figures 3a and b” has been deleted.

[L189: deployment --> development (“deployment” is not the right word); also, add a comma after “vortex”]
Done

[L190-191: lower latitudinal airmasses --> lower-latitude airmasses]
Done

[L193: A problem with the definition of R2 is that, as shown later in the paper, the onset of strong HNO_3 depletion actually begins in mid-May in most years.]
Changed to: “R2, which extends from June to October, follows the onset of the strong decrease in HNO_3 total columns, which starts around mid-May in most years when the temperatures fall below 195 K, and is characterized by a plateau of total HNO_3 minima.”

[L193: add commas after “R2” and “October”]
Done

[L195: the HNO_3 total columns average below --> average HNO_3 total columns are below]
Done

[L198-199: To avoid the potential for confusion with SSWs: Despite the stratosphere warming with 50 hPa temperatures up to 240 K --> Despite 50 hPa temperatures increasing up to 240 K]
Done

[L202: by the PSCs sedimentation --> by sedimentation of PSCs]
Done

[L203: add “e.g.” to the list of references]
Done

[L203-204: add commas after “2012)” and “2016)”]
Done

[L204-205: The meaning of “can hardly be inferred” is ambiguous. I expect that the lack of sensitivity of IASI total column HNO_3 to the LMS precludes detection of renitrification from those measurements. Thus: can hardly --> cannot]
Done

[L206: where --> when]
Done

[L210: occurs --> occurred]
Done

[L212: HNO_3 total columns in 2010 were higher in September as well as in July and August.]
Changed to: “in July - September”

[L219: add “and” after “(R2),”]
Done

[L220: Based on Figure 3a, the plateau of low HNO_3 abundances begins in July, not August.]
Corrected

[Figure 3c:
o Figure 3a clearly shows that the “strong and rapid HNO_3 depletion” (as stated also in L219) occurs mainly during June, so why is the steep drop in HNO_3 in Figure 3c labeled “Jun-Aug”?
The strong HNO3 depletion starts in June and the minima in HNO3 levels are reached in July or August. Based on Fig. 3c, it is quite hard to dissociate these months.
o I do not find the regime markers (R1, R2, R3) on this panel particularly helpful – these labels are essentially floating in semi-arbitrary positions on the plot and convey no real meaning.
We agree that the regime markers are already clearly mentioned in Figures 3a and 3b, but, for more consistency, we believe it is useful that they are indicated in Figure 3c as well.
o It is stated that this panel “highlights the interannual variability in total HNO_3” (L221). But interannual variability is much easier to interpret in Figure 3a. For example, the anomalous behavior in July–September 2010 so evident in panel (a) does not stand out in panel (c). In fact, I would argue that it is

not necessary to color-code the lines by year in panel (c), as the details of individual years are better seen in panel (a) anyway. Just having 10 separate lines would still illustrate the interannual spread even without distinguishing the specific years. If the lines are not color-coded by year, that would allow them to be color-coded in adifferent manner. For example, 12 different colors could be used to indicate the portions of the curves corresponding to each month. This would allow the interannual variability in different months to be compared at a glance. In addition, different line styles (e.g., solid, dashed, dotted) could be used to differentiate the three regimes. Reformulating the plot along these lines would make this panel much more useful than it currently is.
As suggested, we have tried to color-code the lines in order to represent the portions of the curves corresponding to each month, but the dissociation of the months is not that evident with superposition of the HNO3-temperature values over the previous month and the next month, which makes the plot quite hard to visualize. We concluded for this reason that it is better to keep Figure 3c as it is, with one color per year.
o Please add minor tick marks on the axes (x and y) of all of the panels in Figure 3.]
Done

[L221-222: The two parts of this sentence ("highlights the interannual variability in total HNO_3" and "shows a strong consistency in the onset of the depletion between each year") seem contradictory. If the behavior is consistent from year to year, then interannual variability is small. The sentence should be re-written using more careful language. The wording is also awkward: shows a strong consistency --> is very consistent; between each year --> every year.]
Rephrased as follows:
"Figure 3c also highlights a large interannual variability in total HNO_3 in R3, while the strong depletion in HNO_3 in R2 is consistent every year"

[L223-224: Given the span of PSCs formation over a large range of altitudes --> Given that PSC formation spans a large range of altitudes]
Corrected as suggested

[L224: et al., 150 2006 --> et al., 2006]
Done

[L225: that of maximum IASI sensitivity to HNO_3 --> that IASI has maximum sensitivity to HNO_3]
Done

[L229: larger temperatures --> higher temperatures]
Done

[L230: The corresponding R2 temperature at 50 hPa to which the ~180 K value at 30 hPa and the ~185 K value at 70 hPa are being compared is not clear in this discussion.]
As stated in the manuscript, the relationship between HNO_3 and temperature has been tested at two other pressure levels, namely 70 and 30 hPa. The results exhibit a similar HNO_3-temperature behavior at these levels with lower and higher temperatures in R2, respectively, at 30 hPa and at 70 hPa, but still below the NAT formation threshold at these pressure levels. Temperatures down to ~180 K at 30 hPa and down to ~185 K at 70 hPa as compared to temperatures down to ~182 K at 50 hPa are observed. It is now better explained in the corrected manuscript.

[L234: enabling the PSCs formation --> enabling PSC formation]
Done

[L234-235: The "onset of the strong total HNO_3 depletion" in Figure 3c clearly occurs more than 5 K below 195 K (i.e., well to the left of the vertical red line). So I do not see how this statement about the consistency between 195 K and the onset of HNO_3 depletion is supportable. Perhaps the authors are accounting for the fact that HNO_3 starts to condense at temperatures 2–4 K below T_{NAT}, but (a) if so they need to state that explicitly, and (b) the difference in Figure 3c is larger than 4 K.]
From Fig.3a, it is true that the onset of the HNO3 depletion occurred in June with temperatures ranging from ~188 K to ~195 K. Note, however, that (as mentioned in the manuscript and the caption), Fig. 3c represents the evolution of daily averaged HNO_3 total columns with the highest occurrence; it is not based on averaged values as in Fig.3a. To avoid misunderstanding, "Fig. 3c" has been deleted in the last sentence of the paragraph.

[L251: areas --> area; also, the fact that the PV value specified is for 530 K should be stated]
Done

[L252: regions --> region]
Done

[L253: total HNO_3 depletion occurs --> the largest depletion of total HNO_3 occurs]
Done

[L258: I have no idea what "as the daily second-difference HNO_3 total column" means. The rest of the sentence makes sense, so perhaps this part could simply be deleted. Otherwise, if it is supposed to convey important information, then it has to be rephrased for clarity.]
It indicates that the second derivative of HNO_3 total column with respect to time is calculated as the daily second-difference "in" HNO_3 total columns. "in" has been added in the sentence.

[Figure 4 and its caption:
o Why is the red line at 195 K dashed? Similar lines in Figure 3 were solid, which would be a better choice here too as the temperature time series is also shown as a red dashed curve.
The red line at 195 K is now solid as suggested.
o L482: temperature --> 50 hPa temperature]
Done

[L262: around the 195 K threshold --> around the time that temperatures drop below the 195 K Threshold]
Done

[L262: "some days" suggests to the reader "a few days", whereas 23 days is more than 3 weeks. Thus: within some days --> within a few days to a few weeks]
Done

[L265-266: The drop temperature in 2014 does stand out to some degree, but nevertheless I do not think that it can simply be excluded from the IASI-mission average just because it is a bit of an outlier. Strong justification is needed to exclude any individual year from the climatological mean, otherwise the authors risk being perceived as "cherry-picking" their results.]
Cfr comment [L28] above. The year 2014 is now taken into account when calculating the 50-hPa average drop temperature. The 50-hPa average drop temperature has, hence, been corrected consequently.

[L269-270: It is very good to remind readers of the meaning of the term “drop temperature”, but this definition should come earlier in this section since the term has already been used above (L264, L266).
Corrected

[L270: PSCs formation temperature --> PSC existence temperature]
Done

[L271: could reflect the preponderance by one --> could reflect variations in the preponderance of one]
Done

[L276-278: The average drop temperatures for 30 and 70 hPa appear to have been calculated over the full 10-year record, which supports my contention that 2014 should not be excluded from the 50-hPa average drop temperature calculation.]
See the response to the comment [L265-266] above. 2014 is now included in the calculation of the 50-hPa average drop temperature.

[L284: zonal distribution --> climatological zonal distribution]
Done

[L285: Does Figure 5 use geographic or equivalent latitude? If the former, the difference from other figures (which use EqL) needs to be explained, but in any case it should be made clear.]
Both Figures 5 and 6 which represent zonal distributions use geographic latitudes. This is now clearly mentioned in the revised figure captions. The use of equivalent latitude does not make sense here.

[L287: It is stated that one isocontour of 50 hPa temperature is overlaid, but actually two are shown in Figure 5.]
Corrected in the text.

[L289: lines indicates --> line indicates]
Done

[L290: The average drop temperature is given here as 194.2 ± 3.8 K, but above in L265 it was stated to be 194.1 ± 2.8 K. These values need to be reconciled.]
See responses to the comments [L265-266] & [L276-278] above: 194.2 ± 3.8 K is the 50-hPa average drop temperature including the year 2014, while 194.1 ± 2.8 K is the 50-hPa average drop temperature when 2014 is excluded. As suggested by the referee, the year 2014 is now taken into account in the revised manuscript when calculating the average drop temperature.

[L290: rate in --> rate of]
Done

[L291: delete “of some days”]
Done

[Figure 5 and its caption:
o Figure 5b is referred to in L284, but there is no further discussion of this panel in the text. The relationship between IASI total column HNO_3 and 50 hPa temperature has already been investigated in connection with Figures 3 and 4; moreover, Figure 5a includes two contours of 50 hPa temperature.

Thus, in the absence of specific discussion about it in the text, Figure 5b seems superfluous and should be deleted]

The two contours of 50 hPa temperature are now clearly specified in the revised text and Figure 5b is now discussed: " … and the isocontours for the 195 K temperature (pink) and for the averaged 194.2 K drop temperature (purple) at 50 hPa. They further illustrate the relationship between the IASI total HNO_3 columns and the 50 hPa temperatures." "… It shows that the strongest rate of HNO_3 depletion occurs on average end of May, a few days after the temperature decreases below 195 K.".

[o L493: As noted above for the main text, whether this is geographic or equivalent latitude needs to be made clear.]

Done

[o L496: The meaning of "The vertical grey dashed lines encompass the period of the second derivative minima" is unclear – the steepest rate of decrease occurs on a particular date each year, not over a prolonged period. What I believe the authors are trying to say is that the grey lines mark the earliest and latest dates for the drop temperature in the 10-year record, but this statement needs to be written more clearly.]

Re-written as suggested

[o Panel 5b: the date labels (which are nearly illegible) for the overlaid lines indicate that the earliest drop temperature date is 12 May, whereas in L263 it is stated to be 11 May.]

Corrected

[L295: The PV contours are specified at 530 K, not 50 hPa.]

Corrected

[Figure 6 and its caption:

o In the case of Figure 6, panel (b) is not even mentioned in the text. It should be deleted.

For the purpose of the illustration, we would prefer to keep the figure as it is. Figure 6b is now discussed in the revised version: "… as well as the reproducibility of the NAT threshold temperature region that encompasses the inner vortex core. Except for the year 2009, the dates for the strongest rate of HNO_3 depletion matches those for the onset of decreasing temperatures below 195 K.".

o The x-axis date labels are illegible.

The labels have been enlarged in the revised version

o L501: Again, whether this is geographic or equivalent latitude needs to be made clear.]

Done

[L302-305: I'm a little confused about how the -8×10^{-5} $Km^2kg^{-1}s^{-1}$ contour of PV comes into the analysis in this section. It is a bit jarring to state in one sentence that the figure examines the region delimited by the −8 PV contour and then in the next sentence characterize the −10 PV contour as delimiting "the region of interest". I presume that the authors want to investigate a region larger than that of the strong depletion in total HNO_3 (encircled by the −10 PV contour) while excluding the collar region (−5 PV contour), but that rationale should be stated explicitly.]

This was indeed our intention. The text has been clarified as suggested: "… inside a region delimited by a PV value of -8×10^{-5} $K.m^2.kg^{-1}.s^{-1}$ for each year of the IASI period in order to investigate a region a bit larger than that of the strong depletion in total HNO_3 encircled by the PV isocontour of -10×10^{-5} $K.m^2.kg^{-1}.s^{-1}$, averaged over the 10 May – 15 July period for each year, which delimits our region of interest (in green)."

[Figure 7:

o Similar maps of the corresponding dates are not shown, but they would be a useful addition and would help to clarify some points in the discussion, as noted below.

Such a figure is provided for the referee in Figure 1 below. We find it, however, not necessary for the paper.

o The dark green color for the −10 × 10^{-5} $Km^2kg^{-1}s^{-1}$ PV contour does not show up well (at least not on my monitor). A brighter green would work better.

The color of that PV contour has been changed for clarity.

o Why are some of the temperature contours not closed?

The contours are not closed in case of missing values for the gridded temperatures.

o The fonts for the years in the map titles in the top row look odd.

We do not see odd fonts for the years in the map titles.

[L303: delete the comma after "s^{-1}"]

Done

[L303-307: Switching back and forth between temperature and PV makes these lines harder to follow. It would be better to discuss both the averaged and the minimum PV contours together and then move on to the two temperature contours.]

Changed as suggested.

[L306: The PV contour is specified at 530 K, not 50 hPa.]

Done

[L307: Add a comma after "period".]

Done

[L308-309: I have several comments on this part of the analysis:

o The range of 50 hPa drop temperatures found here is considerably broader than that found in connection with Figure 4 in Section 4.1 (~180–210 K vs ~189–203 K), as is the range of corresponding dates (mid-May to mid-July vs mid-May to early June). These differences between the results based on vortex averages and those based on 1°×1° bins should be commented on in the text. Do the two approaches agree in terms of which years show generally lower/higher drop temperatures or earlier/later dates? The discrepancies are of concern because the only advantage that the IASI HNO_3 total column measurements bring over vertically resolved HNO_3 data sets (for which vortex averages can be calculated) is their dense horizontal sampling.

Indeed, the 50 hPa drop temperatures represented on figure 7 and the corresponding dates are broader than the those reported on Figure 4 that represents average values inside the region delimited by a PV isocontour of -10×10^{-5} $K.m^2.kg^{-1}.s^{-1}$. Hence, the two figures are complementary and don't show any mismatch. For instance, the year 2014 that shows the highest drop temperature in Figure 4 is indeed characterized by the highest drop temperatures calculated above the eastern Antarctic. It is now clearly mentioned in the revised manuscript.

o The high extremes in the drop temperature are attributed to issues with the retrievals over eastern Antarctica that are not fully screened out by quality control measures. But Figure 7 shows that unrealistically high drop temperatures are not confined to eastern Antarctica.

This is true, but inside the inner vortex core delimited by the PV isocontour of -10×10^{-5} $K.m^2.kg^{-1}.s^{-1}$, averaged over the period 10 May – 15 July, most of the unrealistic drop temperatures are found above the eastern Antarctic.

o As mentioned above, maps of the corresponding dates would be illuminating. What is the spatial distribution of late dates vs early dates? Do those patterns match the variations in drop temperatures, or do they bear no relation to the temperatures?

As already stated in the manuscript, the area enclosed between the two isocontours of 195 K for the temperatures, the averaged one and the one for the minimum temperatures, shows generally higher drop temperatures and less pronounced minima in the second derivative of the HNO_3 total column with respect to time, as well as later corresponding dates (after the strong HNO_3 depletion occurs in the inner vortex core, i.e. after the 10 May – 15 July period considered here). This indicates strong relationship to the temperatures. As suggested by the referee, similar maps of the corresponding dates are shown in Figure 1 below for the purpose of the illustration. We can clearly see that the early strong depletion (before 15 June) occur inside the isocontours of -10×10^{-5} $K.m^2.kg^{-1}.s^{-1}$ at 530 K for the averaged PV.

o The authors need to directly confront in the paper the fact that dates as late as mid-July for the onset of HNO_3 depletion in the Antarctic are even more implausible than drop temperatures as high as 210 K. These findings will likely cause many readers to dismiss their analysis methodology and/or the use of IASI data for studying PSCs.]

We thank the referee for this recommendation. Some careful sentences were already in the manuscript with respect to these but the word unrealistic has now been introduced twice to make it fully clear. I.e. "Mixing with these already depleted airmasses could also explain the higher drop temperatures detected in those bins. These sometimes unrealistic high drop temperatures are generally detected later (after the strong HNO_3 depletion occurs in the inner vortex core, i.e. after the 10 May – 15 July period considered here – not shown), which supports the transport, in those bins, of earlier HNO_3-depleted airmasses and the likely mixing at the edge of the vortex."

In addition, it is also stated that: "Except above some parts of Antarctica which are prone to larger retrieval errors and where unrealistic high drop temperatures are found, the overall range in the 50 hPa drop temperature for total HNO_3 inside the isocontour for the averaged temperature of 195 K typically extends from ~187 K to ~195 K, which falls within the range of PSC nucleation temperature at 50 hPa". "… and where unrealistic high drop temperatures are found …" has been added here to underline the high drop temperatures calculated over Antarctica.

[L311 & 313: surface --> surfaces]
Done

[L318: Some years have sizeable regions with drop temperatures below 195 K that are well outside the averaged 195 K contour. Hence, encircles well --> encircles fairly well.]
Done

[L319: bins inside that area characterize air masses --> bins inside that area include air masses]
Done

[L322 & 325: show --> shows]
Done

[L327: is also enclosed --> is also typically enclosed]
Done

[L330-331: The weakest minima in the second derivative of total HNO_3 (not shown) observed in that area indicate a weak and slow --> The fact that the weakest minima in the second derivative of total HNO_3 (not shown) are observed in that area indicates a weak and slow]
Done

[L333-334: Although I think it is good to point out the possible impact of mixing on these results, it should also be acknowledged that previous studies have shown that in the Antarctic mixing between the edge region and the vortex core is generally weak (e.g., Roscoe et al., JGR 2012).]
It is now clearly mentioned in the revised version as suggested: "Note, however, that previous studies have shown a generally weak mixing in the Antarctic between the edge region and the vortex core (e.g. Roscoe et al., JGR 2012)."

[L333: reflect a mixing with strong --> reflect mixing with strongly]
Done

[L334: The mixing --> Mixing; explained --> explain]
Done

[L335-336: I'm confused by this sentence. The drop temperature is defined by the onset ofHNO_3 depletion, so how can it be that high drop temperatures are detected "after the HNO_3 depletion occurs"?]
It has been clarified in the revised text: "after the strong HNO_3 depletion occurs in the inner vortex core, i.e. after the 10 May – 15 July period considered here".

[L338-339: What is meant by "the range of maximum sensitivity of IASI to HNO_3"? Elsewhere in the manuscript, it is stated that IASI has the largest sensitivity to HNO_3 in the 30–70 hPa range, but how is that altitude information relevant to the spatial variations in the maps of Figure 7?]
Changed to: "these spatial variations might also partly reflect some uncertainty into the drop temperature calculation, introduced by the use of temperature at a single pressure level (50 hPa) and of PV on a single potential temperature surface (530 K) while the sensitivity of IASI to changes in the HNO_3 profiles extends over a range from ~30 to ~70 hPa during the polar night."

[L339-346: The second half of the sentence in L339 ("while biases …") starts a new discussion on reanalysis temperature and is followed by several related sentences, so it should be a separate sentence (not starting with "while"). In addition, it is not clear to the reader why all of the detail presented in the following sentences is really necessary. It would be better to either end the paragraph by stating explicitly that ERA-I temperature biases of the magnitude noted in these lines could not possibly account for the large range of calculated drop temperatures, or simply delete some of the details.]
This sentence has been rewritten in order to address the comment of the referee. Details related to the uncertainties in ECMWF ERA Interim temperature have been deleted.

[L339: for explaining --> to explain]
Done

[L344: just to be clear, add "in modern reanalyses" after "reduced".]
This part of the sentence has been deleted (see comment above).

[L348: drop 50 hPa temperature --> 50 hPa drop temperature; delete the comma after "195 K"]
Done

[L349: PSCs nucleation --> PSC nucleation]
Done

[L351: on the type of formation mechanisms --> on the specific formation mechanism (i.e., the type of PSC developing)]

Done

[L353: coverage of IASI that allows capturing the rapid and critical depletion phase --> coverage of IASI, which allows the rapid and critical depletion phase to be captured in detail]
Done

[L357: columns dataset --> column dataset]
Done

[L358: since other IASI instruments are mentioned later: Metop --> Metop-A]
Done

[L363-364: I find this wording unclear. I suggest: level over a range where --> level, which lies in the range where; process occur --> processes occur]
Done

[L367: delete “various”]
Done

[L368: delete “and described along the cycle” (this wording is confusing and unnecessary)]
Done

[L369: delete “at play”]
Done

[L370: Only Antarctica is considered here, thus: in the poles --> over Antarctica]
The sentence “R1 is defined during April and May and characterized by a rapid decrease in 50 hPa temperatures while HNO_3 accumulates in the poles” remains as it is. The strong depletion occurs in the area defined by a PV of -10×10^{-5} $K.m^2.kg^{-1}.s^{-1}$ at 530 K (typically over Antarctica indeed) but HNO_3 accumulates outside that area over the poles.

[L370: As mentioned earlier when this regime was defined, R2 starts in June but the uptake of HNO_3 into PSCs starts in mid-May, as shown in this paper and in previous studies.]
See comment [L193] above. Changed to: “R2, from June to September, follows the onset of the depletion that starts around mid-May in most years when the 50 hPa temperatures fall”.

[L371-372: PSCs nucleation --> PSC nucleation]
Done

[L372: between each year --> from year to year]
Done

[L372: R3 is actually defined (L198, Figure 3a) to begin in October, not November.]
Corrected

[L373: until March --> through March]
Done

[L374: PSCs sedimentation at --> PSC sedimentation to]

Done

[L376: found particularly --> found to be particularly]
Done

[L377: condensation to --> condensation into]
Done

[L379: 2.8 --> 2.8 K; also, as noted previously, the inconsistency in the average drop temperature values given in the text (L265 and L290) needs to be fixed and the correct one quoted here. L380: As noted above in Section 4.1, I do not think that the omission of 2014 from the climatological average is justified.]
Corrected. See our response to the comment [L290] above.

[L381: demonstrated --> demonstrate; PSCs formation --> PSC formation]
Done

[L384: PV at 50 hPa --> PV at 530 K]
Done

[L386: highest minima --> lowest minima]
Done

[L388: "from year to year" is not the right phrase; perhaps the authors mean "in some years"]
Corrected

[L388: As mentioned earlier, not all of the unrealistically high drop temperatures were calculated over eastern Antarctica]
See our response to the comment [L308-309] above.

[L390: found in line --> found to be in line; PSCs nucleation --> PSC nucleation]
Done

[L395-396: It likely results --> These likely result; a mixing --> mixing]
Done

[L399: over the whole polar regions --> over the whole Antarctic region]
Done

[L401-403: I do not see how the authors could make the statement that the IASI dataset offers a new observational means to monitor the relation of HNO_3 to temperature and PSC formation because it can make measurements in darkness. It is certainly understandable that they want to tout IASI's excellent spatial coverage and its potential for a long record. Those are indeed very valuable contributions. But it is simply not acceptable to ignore decades of HNO_3 measurements made "throughout the year (including the polar night)" by numerous satellite instruments (e.g., LIMS, UARS MLS, Aura MLS, CLAES, MIPAS, SMR, ILAS, SMILES).]
It is of course not our intention to ignore the long-time series already available from other instruments, which are referenced in the introduction, but rather to underline the interest of the IASI record for the

future. In order to avoid a feeling of overselling "…IASI dataset offers new observational means to…" has been changed to "…IASI dataset offers a valuable observational means to…".

[L401-402: delete "capturing"; add "to be captured" at the end of the sentence]
Done

[L404: allow to investigate --> allow investigation of]
Done

Figure captions

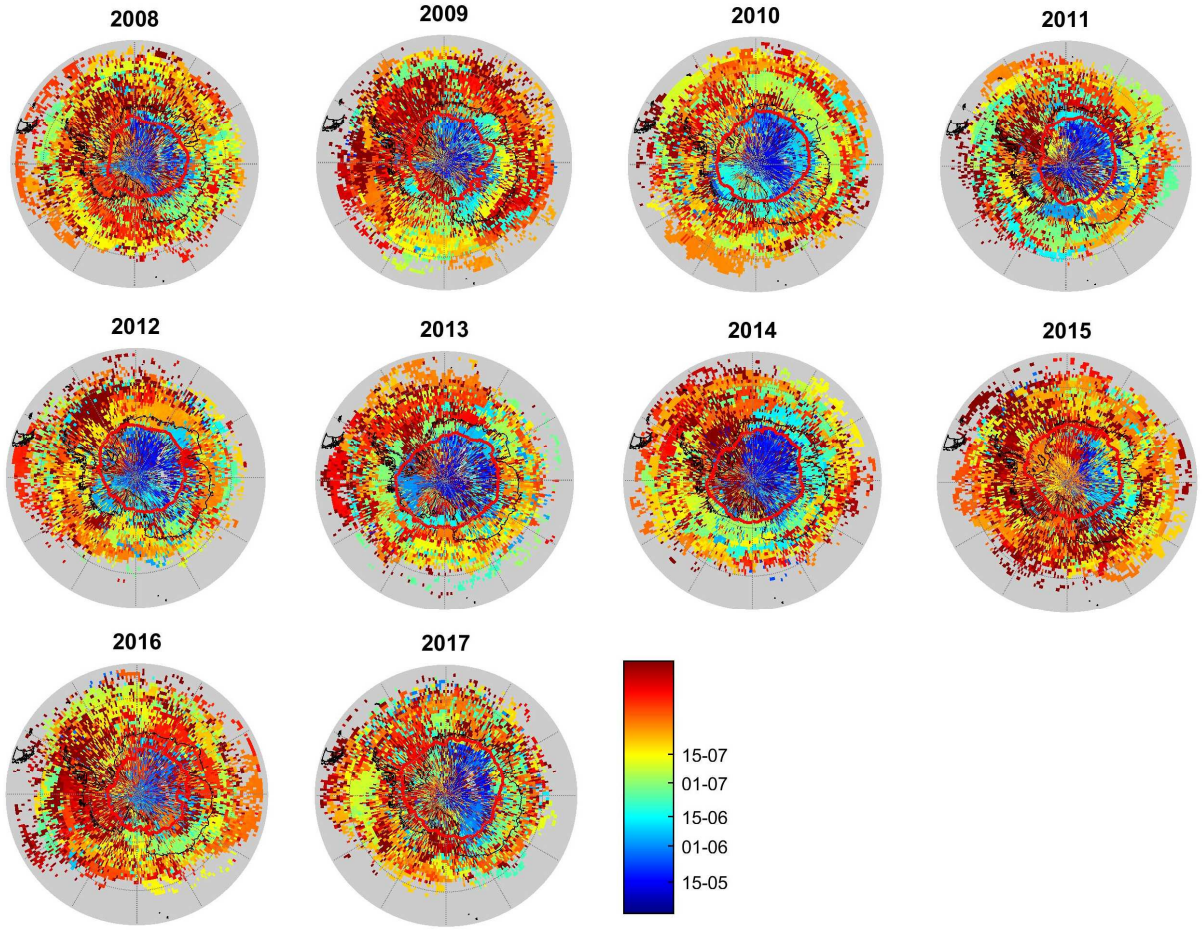

Figure 1. Spatial distribution (1°×1°) of the dates corresponding to the drop temperatures at 50 hPa (calculated from the total HNO_3 second derivative minima) for each year of IASI (2008–2017), in a region defined by a PV of -8×10^{-5} K.m^2.kg^{-1}.s^{-1}. The isocontours of -10×10^{-5} K.m^2.kg^{-1}.s^{-1} at 530 K for the averaged PV (in red) over the same period are represented.