

Re-review of “Polar stratospheric nitric acid depletion surveyed from a decadal dataset of IASI total columns” by Ronsmans et al.

The manuscript has been substantially revised in response to referee comments. In general, the authors have done a good job in responding to the points raised by the reviewers, and the manuscript has been improved. However, a few new issues have been introduced through the revision process. In addition, while some of the concerns noted below have just arisen, others were present in earlier drafts but escaped my attention; they have become more obvious now that most of the significant issues pointed out previously have been remedied. Section 4 in particular requires further clarification in several places.

Respectfully,
Michelle Santee

Substantive issues and minor points of clarification, wording suggestions, and grammar / typo corrections are listed together for each section in sequential order through the manuscript.

Abstract & Introduction:

- L31: It would be better to spell out “equivalent latitude” in the abstract. By the way, this abbreviation is capitalized inconsistently throughout the manuscript (“EqLat”, “eqLat”).
- L48: particles type --> particle type
- L78: This sentence should be rearranged to avoid giving the impression that each of these instruments made measurements for decades: "Over the last few decades, several satellite instruments have measured stratospheric HNO₃ (e.g., ...".
- L85: the HNO3 --> HNO₃
- L88: a series of --> several
- L98: dependence to --> dependence on

Section 2:

- L122-123, 131: The discussion in these lines about “the expected variations of HNO₃ within the polar night”, “HNO₃ profiles retrieved within the dark Antarctic vortex”, and “during the dark Antarctic winter, we clearly see depleted HNO₃” could be misinterpreted to suggest that HNO₃ has strong diurnal variations, when in fact the largest changes in HNO₃ inside the Antarctic winter polar vortex are driven by PSC formation and thus temperature (not directly by sunlight per se). This should be clarified.
- L129: to which extent --> the extent to which
- L132 and Fig. 1 caption: It is slightly confusing that the text refers to values of the total column averaging kernel of ~1 but the plot shows values of 0.1. The statement “(divided by 10)” in the caption (L496) could be interpreted to apply only to the grey sensitivity profiles; it should be made clear that it refers to the black curves as well.
- L134-141: This sentence, which spans 8 lines, is difficult to read. In particular, having such a long and complicated parenthetical statement makes the sentence hard to parse. I suggest rearranging and breaking it up into two or three sentences. In addition, some additional

punctuation would make the statement currently in parentheses easier to read, so I suggest adding commas after “surface” (L136), “0.95” (L137), and “surfaces” (L138).

- L145: profiles → profile
- L146: The term “VMR” has not been defined; since it is not used again in the manuscript, it would be better to simply say “mixing ratio” here.

Section 3:

- L185: (1) The statement that similar histograms are observed for “the 10 years of IASI measurements” is ambiguous and could be interpreted to imply that IASI made only 10 years of measurements. I suggest instead: “Similar histograms are observed for the other years in the 10-year study period.” (2) The horizontal line in Fig. 3a is not red (it appears to be grey).
- L187: The three identified regimes correspond to → The three regimes we identified are:
- L189-196: It should be acknowledged that HNO₃ starts to decrease by the end of this regime. That point is now stated in the description of R2, but it needs to be mentioned for R1 as well.
- L198-200: As noted above, I appreciate that the description of R2 now makes it clear that HNO₃ depletion typically begins by mid-May, but the current wording focuses solely on the low values and ignores the steep decrease at the start of the regime. I suggest rewriting along the lines of: “R2, which extends from June to October, follows the onset of the strong decrease in HNO₃ total columns that starts around mid-May in most years when the temperatures fall below 195 K. After a steep initial decline in HNO₃, R2 is characterized by a plateau of total HNO₃ minima. For much of this regime, ...”.
- L222: over the 10 years of IASI → over the 10-year study period
- L223-225: In fact, Fig. 3c does not “clearly illustrate” the “strong and rapid HNO₃ depletion occurring in June” – it is not possible to differentiate the evolution in June from that in July and August in Fig. 3c. Only in Fig. 3a can we see that the steep drop in HNO₃ occurs in June. A similar comment applies to the start of the plateau in July, also not discernible in Fig. 3c alone.
- L226: HNO₃in → HNO₃ in
- L227-228: As discussed earlier in this section, temperatures actually dip below 195 K in mid-May in most years, not June. The parenthetical part of this sentence could simply be deleted.

Section 4:

- L256-257: A slight rearrangement would make this easier to read: “potential vorticity smaller than $-10 \times 10^{-5} \text{ K} \cdot \text{m}^2 \cdot \text{kg}^{-1} \cdot \text{s}^{-1}$ at the potential temperature of 530 K”.
- L268: The labels for 2013 on Fig. 4 and Fig. 6 say “11 May”, while this sentence and the label on Fig. 5 say “12 May”. Please be consistent.
- L270: the strongest HNO₃ depletion → the strongest rate of HNO₃ depletion; are detected between → are between; add a comma after “198.6 K”
- L271: with an exception for the year 2014 which → with the exception of the year 2014, which
- L292: hence, could only have limited influence on the delimitation → hence, have only limited influence on the identification
- L293: detection → determination
- Fig. 5 caption: add “and” after “530 K” (L549); by a → by the (L553)
- L297-298, 304-305, 308: Again, “over the whole IASI period”, “over the IASI period”, and “over the ten years of IASI” makes it sound as though IASI only operated for 10 years.

- L302-303: The $-10 \times 10^{-5} \text{ K.m}^2.\text{kg}^{-1}.\text{s}^{-1}$ contour of PV demarks the region of strong HNO_3 depletion only until October.
- L303-306: It is stated that “the red dashed vertical line indicates the average date for the 50 hPa average drop temperatures calculated in the area of $\text{PV} \leq -10 \times 10^{-5} \text{ K.m}^2.\text{kg}^{-1}.\text{s}^{-1}$... It shows that the strongest rate of HNO_3 depletion occurs on average [at the] end of May”. The date is not specified in the text, but the red dashed line is labeled “24 May” on Fig. 5. This is several days *before* the blue curve representing the $-10 \times 10^{-5} \text{ K.m}^2.\text{kg}^{-1}.\text{s}^{-1}$ contour of PV appears on the plot. I assume that the climatological (2008–2017) PV contour is shown, although that is not explicitly stated in the figure caption. Please clarify in the text how the “average date” is being calculated. Please explain how it is that the “average date” for the 50 hPa average drop temperatures, which are calculated in the area of $\text{PV} \leq -10 \times 10^{-5} \text{ K.m}^2.\text{kg}^{-1}.\text{s}^{-1}$, precedes by a week or so the existence of a significant area within that PV contour in an average sense.
- L305: average end of May --> average at the end of May
- L306-307: It is then stated that “The delay between the maximum in total HNO_3 and the start of the depletion (see Fig. 4) is also visible in Fig. 5.” Is “maximum in total HNO_3 ” really what is meant here? Total HNO_3 is not shown in Fig. 4 (only the second derivative is shown in that figure) – should this reference be to Fig. 3? What is the point being made here – is this saying that the lag of a few days to a few weeks (depending on the year) between the total HNO_3 maximum and the strongest rate of HNO_3 depletion discussed in L266-268 is also evident in the climatological plot in Fig. 5? If so, then it is not “the start of the depletion” but rather the strongest rate of depletion. In any case, this needs to be written more clearly.
- L307: Delete “For the purpose of the illustrations” (this phrase is confusing and unnecessary).
- L308-312: First, this sentence is long and complicated and could be read as saying that IASI measures PV. Second, the repeatability from year to year of the morphology of the distribution of both HNO_3 and temperature in the southern polar region has been known for decades, shown in numerous prior publications. Therefore I suggest deleting the part about the NAT region and rearranging/rewriting the rest as: “... Fig. 6, which shows that IASI measures similar HNO_3 total column zonal distributions every year, in particular with respect to the edge of the collar region and of the region of strong depletion (respectively delimited by the PV isocontours of $-5 \times 10^{-5} \text{ K.m}^2.\text{kg}^{-1}.\text{s}^{-1}$ and $-10 \times 10^{-5} \text{ K.m}^2.\text{kg}^{-1}.\text{s}^{-1}$ at 530 K).”
- L312-313: The statement “Except for the year 2009, the dates for the strongest rate of HNO_3 depletion [match] those for the onset of decreasing temperatures below 195 K.” seems out of place here – it should have been made in connection with Fig. 4, where it can be seen much more clearly. Moreover, this point seems in conflict with the statement made in L305-306 that “the strongest rate of HNO_3 depletion occurs on average ... a few days after the temperatures decrease below 195 K”. It doesn’t seem to me that the difference in the timing in 2009 is really large enough to produce a mismatch of a few days in the 10-year average – please clarify.
- L313: matches --> match
- L315: It might be good to add “Spatial” in front of “Distribution” in the subsection title.
- Fig. 7: Presumably the temperatures in this figure are taken from ERA-Interim fields, thus there should be no missing values, especially averaged over a 2-month period. Therefore, I still do not understand why some of the temperature contours are not closed (PV contours are closed).
- L317-322: This 6-line sentence is hard to get through. Moreover, a crucial piece of information is relegated to a parenthetical. I suggest rewriting as: “To explore the capability of IASI to

monitor the onset of HNO₃ depletion at a large scale, Fig. 7 shows for each year of the study period the spatial distribution of the 50 hPa drop temperatures based on the second derivative minima of total HNO₃ averaged in 1°×1° grid cells. The region of interest here is delimited by a PV value of $-8 \times 10^{-5} \text{ K.m}^2.\text{kg}^{-1}.\text{s}^{-1}$ in order to investigate an area a bit larger than the inner vortex core that was the focus of the preceding discussion (delineated in green in Fig. 7 by the PV isocontour of $-10 \times 10^{-5} \text{ K.m}^2.\text{kg}^{-1}.\text{s}^{-1}$ averaged over the interval 10 May to 15 July)."

- L327: It might be good to note that this picture is not much different from that seen in the vortex averages, perhaps something like: "... (not shown). Although the range of drop temperatures and dates for 1°×1° bins is broader than that found for the inner vortex averages discussed above, the results are qualitatively consistent. For example, the year 2014 ...".
- L328: highest average --> highest inner vortex average
- L329-336: Is there an explanation for why the retrievals are apparently affected by emissivity issues to a greater degree in 2014 than in other years?
- L350-353: This sentence is awkward and hard to read. Something like this would be better: "The fact that the weakest minima in the second derivative of total HNO₃ are observed in that area (not shown) indicates a weak and slow HNO₃ depletion that might be explained by air masses at the inner edge of the vortex experiencing only a short period with temperatures below the NAT threshold."
- L358: earlier HNO₃-depleted --> previously HNO₃-depleted
- L360: The words "JGR 2012" should be deleted here, and the paper by Roscoe et al. (2012) needs to be added to the reference list.
- L361: uncertainty into --> uncertainty in
- L364: note --> noted
- L365: delete the comma after "work"
- L366: found --> found only
- L368: The "COSMIC" acronym should probably be spelled out.

Section 5:

- L393: in the poles --> over the pole (plural "poles" implies that the Arctic is also examined)
- L394: R2 runs until October, not September.
- L399: IASI period --> 10-year study period
- L403: 3.8 --> 3.8 K
- L410: Many people may not read the main part of the paper in detail and may only concentrate on the Conclusions, so it would be good to replace "extreme" here with "unrealistic".
- L412: in case of --> arising from
- L414: a series of --> several
- L419: results --> result
- L422: regions --> region