

REPLY TO REFEREE #1 (*in italics*)

Referee report for amt-2021-340 (Remsberg et al., Variations of Arctic winter ozone from the LIMS Level 3 dataset)

General Comments:

I found myself somewhat torn regarding the value of this manuscript, which describes a few features of LIMS Level 3 maps and profiles in the context of the Arctic winter of 1978/1979. The motivation seems to be to generate more visibility for this data set for anyone interested in placing those historical ozone fields (or other fields obtained by LIMS) in “context”, given the longer-term changes in and the importance of ozone, in particular. Most of the usefulness of this nice early data set may well have been “milked”, by now, and in large part thanks to the work of the authors of this manuscript. Adding this manuscript at this late stage is not of the highest value, scientifically, or even as a brief data description or as a partial demonstration of validation using Level 3 data. Nevertheless, it is not technically incorrect or flawed, and there may not be enough published research of mesospheric variations, which are reported on to some extent here. I also found that the flow and focus of the manuscript were not that easy to follow. Finally, there are also some data limitations in the case of LIMS (non-LTE effects mentioned in the manuscript) for parts of the upper atmosphere, as mentioned by the authors.

I do (somewhat marginally) recommend publication in AMT (or a data-type Journal, possibly, if not in AMT), mainly for “historical” reasons. A few minor comments for details and clarity should be addressed (see below); there is nothing major, except for that somewhat “agonizing” part over the worthiness of this publication at this time, since it does not add much to the science and there are clearly more recent studies using many more years of data from other instruments (as referenced in this manuscript), even without the use of synoptic-type maps. It is also not so much of a “measurement technique” type of paper, but this may still be the best option.

General comments—We thank the reviewer for a careful assessment of the manuscript, and we understand his/her ambivalence regarding its suitability for AMT. We initially submitted this manuscript to Earth System Science Data (ESSD) journal, but no associate editor agreed to handle it. Therefore, we opted to send it to AMT. To improve the flow of the manuscript, we are moving several figures to Supplemental materials—Fig. 8 that showed lower mesospheric ozone and temperature on January 27 (now Fig. S1) and figures showing three panels of H₂O and three panels of temperature at 0.022 hPa (Figs. S2 and S3). A separate important aspect of the V6 Level 3 dataset is that its daily maps show more clearly the strong horizontal gradients at the polar and subtropical edges of ozone streamers, at least compared with those presented in Leovy et al. (1985)—see example in Fig. S4. We rescaled the panels in Figs. 4-7 and rearranged the panels in Figs. 9-11. New Fig. 9 now shows two NO₂ panels—one at 4.6 hPa and another at 3.2 hPa, indicating that there may have been some downward transport of NO₂ in the region of the LOP. Fig. 9 also shows a relative maximum in HNO₃ at 4.6 hPa. Figure 10 shows the three ozone panels that were in original Fig. 10. Figure 11 has an ozone and a temperature panel—for December 15, showing the relation of temperature with the tertiary ozone feature but now based on combined (A+D) ozone. Three more ozone and their corresponding temperature panels are in Figs. S2 and S3 to indicate their changing structure across the Arctic region during winter. Fig. 12 is new and

shows a time series of the tertiary ozone feature. Figures 9-12 provide more insight about the value of the V6 dataset for science studies of the separate LOP and tertiary ozone features.

The relevant new figures are at the end of our response.

Mostly minor/editorial-type comments:

We have incorporated your editorial suggestions and/or added a reference, where needed. In addition, we comment on several of your specific concerns/questions in the following.

- P2, L32, “heights” rather than “height”, since this is a sequence of heights.
- P3, L53, too many “report on” in these last few sentences of this paragraph. Try using “describe”, for example, here, instead.
- P3, L56-57, these two sentences use the past tense, and it would be best to use either present or past for the whole paragraph (e.g., use present in these two sentences also).
- P3, L61, I think you really just mean “(Level 2)”, since there is also a V6 Level 3 data set.
- P4, L102, delete “all” in front of “latitudes”.
- P4, L104, I would delete “, or 33.5 deg counterclockwise...vector” as this is the same sort of statement as the first part of the sentence (but just turned around).
- P5, L107, I would use “well registered” rather than “registered well”.
- P5, L110, it would seem that the latitudinal spacing represented by the samples in Fig. 4 is coarser than 1.6 degrees; is this just the mapping algorithm (coarser) grid [maybe I missed this part]? If this is described well enough in the manuscript, no need to change anything.

P5, Line 110--You raise a good point. Each LIMS up/down, horizon scan pair yields a single retrieved V6 profile that is separated from the next profile by 144 km along the orbital tangent track (or by 1.3° at low to middle latitudes, instead of 1.6°). The V6 data in Fig. 4 (top) are for every other profile along the viewing track near White Sands and have spacings of 2.6°. The Level 3 zonal coefficients were analyzed at every 2° of latitude, based on tangent track profiles closest to that latitude. We have revised the manuscript, accordingly.

- P6, L136, no need to redefine SPARC Data Initiative as SPARC-DI (was done earlier), just use one or the other...

- P6, L158, The sentence should be reworded better, e.g. “To first-order, the stratospheric T(p) retrievals account for the effects of horizontal temperature gradients” [+ I would have liked to see a reference regarding the methodology here, even if it might be much more obvious to the authors themselves]. It is hard for the reader to understand this otherwise, and this is either stretching the long-term memories of some or asking too much (literature search) from an interested younger reader.
- P6, L159 (and in general), what do “errors” reflect in this manuscript? Are they estimated 1-sigma-type errors, or double this? Please specify this somewhere (assuming that all error bars represent, say, 1-sigma).

P6, Line 159--V6 profile errors are root-sum-squared (RSS) errors, as defined from the LIMS error analysis studies. We added the reference, Remsberg et al. (2021).

- P6, L161, I suggest a slight rewording: “...bias error for ozone, and these errors grow to about 16% in the middle mesosphere...”
- P7, L173/174: how exactly is it known that the larger SD values are caused by planetary wave activity? Because of their magnitude and extent? Please specify what is known (with a reference, possibly).

P7, Lines 173/174--Monthly SD values are the zonal standard deviations about daily zonal means, followed by taking their monthly average. Although gravity waves are not of the scale of planetary waves, they are of a spatial scale at Arctic latitudes that contributes to zonal SD values.

- P7, L175/176, this statement would also be better with at least one reference regarding the upward propagation part (and there are certainly references for this).
- P7, L183, “The estimated total error for CHEM...”
- P8, 205: Here, the sonde data are referred to as "Datasonde" rather than chemiluminescent sonde, or just CHEM (as done for Fig. 4 and associated discussions). Either call all the sonde data "CHEM" (short for chemiluminescent sonde), or make it clear when "Datasonde" is introduced that this is the same as "CHEM"... but in my view, one consistent notation (either CHEM or Datasonde) would be better, unless you have a good reason to keep changing notations. I should note that the Hilsenrath (1980) paper never mentions "CHEM", but they do mention chemiluminescent sonde and (one occurrence of) "Datasonde".

P8, Line 205--We no longer make use of the acronym CHEM. The Datasonde provides the temperature profile from a nearly co-located, separate rocket sounding.

- P8, L211, “are well determined along...” [might be better]
- P9, L239, “and relatively low temperatures” [or “and is relatively cold”]
- P9, L244, “at 0.46 hPa or above in the Alaskan anticyclone”?
- P10, L257, “from studies of GPH...”
- P10, L258, “They determine the extent...”
- P10, L260, delete the comma before “vertical resolution”
- P11, L263, the vertical resolution has already been defined (3.7 km)

- P11, L286/287, what about downward transport from higher altitudes, is that not also possible / part of the equation?

P11, Lines 286/287-- Downward transport may be happening in the region of the LOP. To infer that, we now show two maps of NO₂ in revised Fig. 9—one at 4.6 hPa (as before) and another at 3.2 hPa—and a map of HNO₃ at 4.6 hPa.

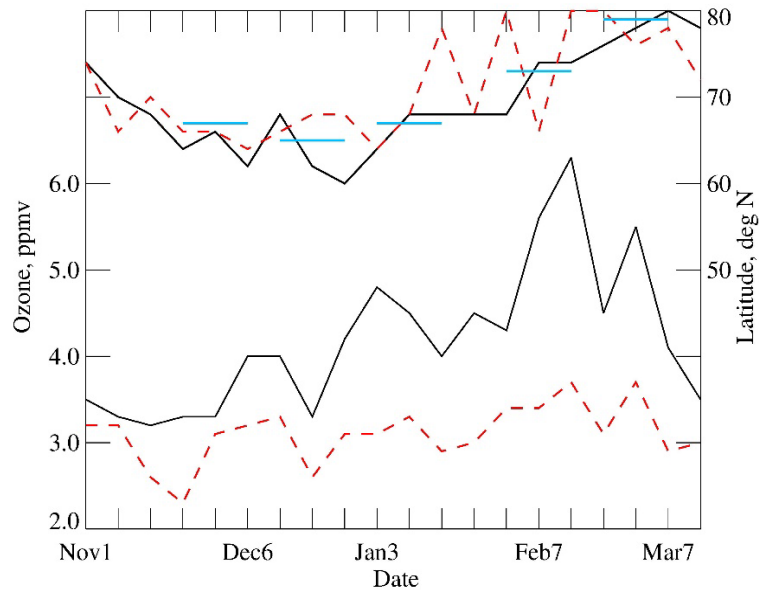
- P11, L288, NO_x includes NO₂...so you could delete “(and NO₂)”
- P11, L294, “some chemical loss of ozone...”
- P11, L295, “indicates that there were significant variations...”
- P12, L318, “temperatures are much higher in the Canadian sector...”
- P13, L344, delete “, too”
- P14, L371, I would think that with less than one year of data, a baseline is somewhat difficult to establish (given seasonal and QBO effects), but the statement is sort of alright.
- P14, L388/389, it is way too late to reconsider validation efforts for LIMS, in my view, or to add much to past work from such an effort. P14, L393/394, this sentence is too nebulous (what does one may find mean?), in large part because this is probably too difficult to accurately assess, given the short period of data from LIMS, in my view. Of course there are changes, but accurately determining an underlying trend requires a good amount of nearly continuous data between “recent decades” and 1979. Also, the community knows that SAGE data have been used for this purpose.

P14, L393/394--We delete this sentence and no longer emphasize the use of V6 data for long-term trend studies.

- P15, L396, “surface maps” means what (why not just “maps”)?
- Figure 4, one should be able to know which two satellite profiles are immediately adjacent to the CHEM profile. Please specify in the caption.
- P33, L626, please provide all author names for this reference.

Figures--

Below we show new Figure 12. We also show the second NO₂ panel (for 3.2 hPa) and an HNO₃ panel at 4.6 hPa for revised Figure 9. Fig. S4 of the Supplemental Materials compares V6 ozone for January 27 at 10 hPa with a similar map from Leovy et al. (1985).



New Figure 12--Time series of peak V6 daily ozone at 0.022 hPa and its latitude location, as plotted every 7 days.

The time series are for peak ozone (bottom two series) and their latitude locations (top two). Dashed red curves represent zonal mean results for the combined (A+D) data; solid black curves are results for nighttime (D) only. Blue horizontal lines represent latitude position of the terminator at 30 km altitude.

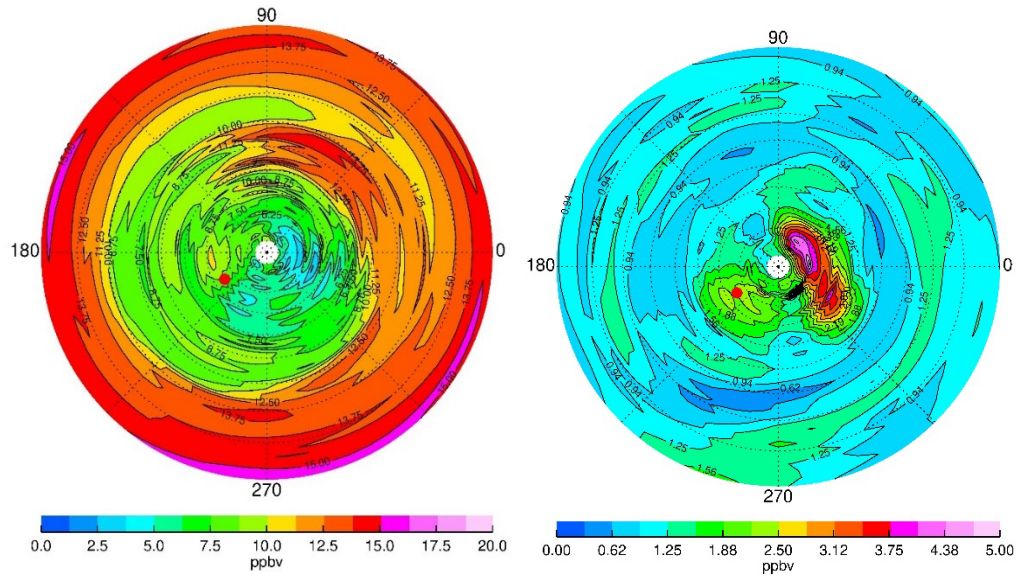


Figure 9—Additional panels (at left) of NO₂ at 3.2 hPa and (at right) of HNO₃ at 4.6 hPa on January 27.

New figure for Supplemental Materials--

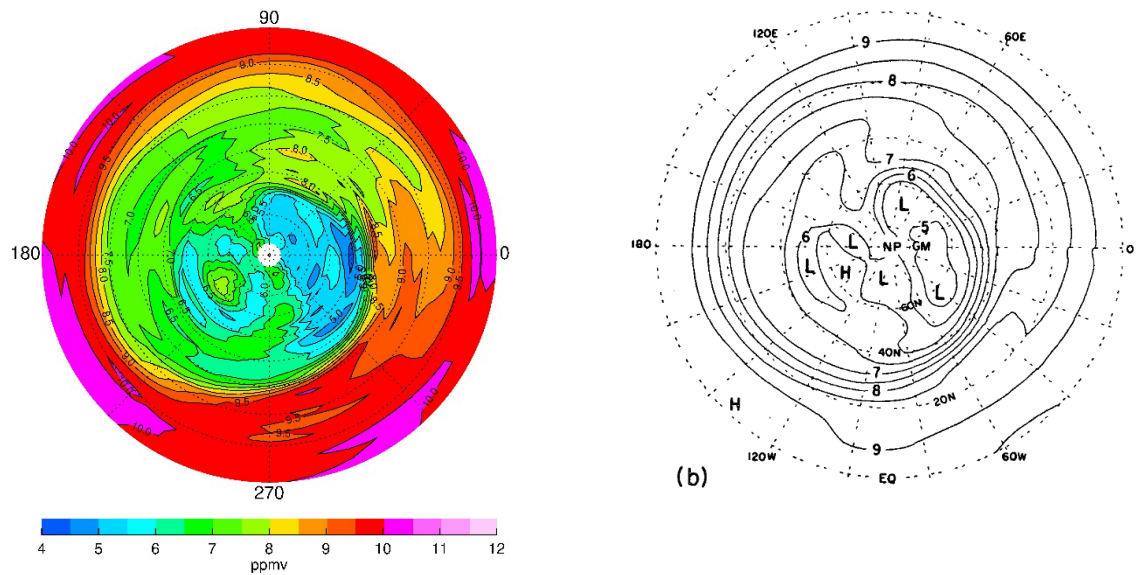


Fig. S4—Comparison of ozone at 10 hPa for 27 January from (left) V6 versus (right) Leovy et al. (1985).