Review of "Comparison of Inorganic Chlorine in the Southern Hemispheric lowermost stratosphere during Late Winter 2019" by Jesswein et al.

This paper analyzes in situ measurements of halocarbons and N_2O obtained during the 2019 SouthTRAC and 2015/2016 PGS HALO aircraft campaigns. Air masses are classified as belonging to vortex, edge, and mid-latitude regions. Estimated Cl_y abundances in the two hemispheres are compared. Although the measurements and the derived Cl_y profiles will be of interest to the readership of ACP, in my opinion the manuscript suffers from a number of flaws in the analysis and/or the description thereof. Consequently, I have a rather large number of specific comments that I would like to see addressed before the paper can be accepted for publication. In some cases, my concerns can be resolved by simply correcting and clarifying the discussion, but others will require additional analysis or other substantial changes.

Below both major substantive issues and minor points of clarification, wording suggestions, and grammar / typo corrections are listed together for each Section (including Supporting Information) in sequential order through the manuscript.

Respectfully,
Michelle Santee

Title

- The comparison being made in this paper is not clear from the title. It would be better to craft a different title capturing the idea that in situ measurements from separate aircraft campaigns are being used to compare Cl_y abundances in the Antarctic and the Arctic LMS.

Abstract

- L1: The wording "… long-lived chlorinated source gases. These include the reservoir species" seems to imply that HCl and $ClONO_2$ are chlorinated source gases. Thus, These include --> Cl_y includes
- L5: in late winter --> in austral late winter
- L8: The sentence "Cl_y from a scaled correlation was compared to directly determined Cl_y …" is confusing, since the previous sentence states that not all source gases were measured during PGS. It needs to be made clear that this "validation" was performed for SouthTRAC.
- L12-13: The values (40%, 20%) here appear only in the abstract and conclusions, not in the main text. In my opinion, it is not appropriate to include "new information" in the abstract and summary sections that has not been thoroughly discussed in the body of the paper. Please add some corresponding statements in section 4.
- L13-14: Differences inside the respective vortex reaches up to 565 ppt more --> Differences inside the two vortices reach as much as 565 ppt, with more
- L15-16: As far as is known --> To our knowledge; within the respective polar vortex --> within the Antarctic and Arctic polar vortices
- L16-17: "the difference of Cl_y inside the respective vortex is significant and larger than reported inter annual variations". I have a number of comments on this sentence:
  - The authors have not done a statistical analysis, so I do not think that "significant" is an appropriate word here.

- This statement could be erroneously interpreted as implying that their study examines interannual variations. Moreover, the Strahan et al. [2014] paper on which this statement is based looked only at the Antarctic, not the Arctic.
- The word "respectively" is used many times throughout the manuscript, sometimes (as here) incorrectly. I have recommended alternative wording in a few places.
- Thus, I suggest instead: "the differences in Cl_y inside the two vortices are substantial and larger than the interannual variations previously reported for the Antarctic".

Section 1

- L20: 1980-ies --> 1980s; also, pre-dominantly --> predominantly
- L23: substances, which are involved --> substances involved
- L23-24: OClO is a consequence of, and thus a good qualitative indicator of, halogen activation, but it does not itself participate in ozone destruction, as this sentence implies. Thus it is not normally considered part of ClO_x.
- L25: within --> through
- L26: While I applaud the recognition of some of the original papers, I think it would be good to also include some review articles (e.g., Solomon, Rev Geophys, 1999) and/or some more up-to-date citations (e.g., the most recent WMO Ozone Assessment).
- L30: Citing only the Newman et al. [2004] paper here gives the erroneous impression that it is the only relevant reference. At the very least, "e.g.," needs to be added to this citation. This is another instance where it might be appropriate to cite the WMO Report.
- L35: used again --> again used
- L39-40: Citations for the long-term trends in Cl_y and N_2O should be given.
- L45: between polar --> between the polar
- L46: Here and throughout the manuscript, when "mid-latitudes" is used as an adjective to modify a noun (e.g., stratosphere, profile, reference, etc.), it should be singular: "mid-latitude". When it is used as a noun itself (as in "at mid-latitudes"), then it is plural.
- L46: add "e.g.," in front of "Schoeberl"
- L48: add "e.g.," in front of "Hartmann"
- L62: SouhTRAC --> SouthTRAC
- L65: delete duplicate period after "4"

Section 2

- L70: capable to reach --> capable of reaching
- L72: Rio Grande (RGA), Argentina (53°S, 67°W) --> Rio Grande, Argentina (RGA, 53°S, 67°W); also, regions for --> regions of
- L74-75: The actual dates (not just "September" and "November") for the two phases of the campaign should be given.
- L77-80: 9 transfer flights + 10 Phase I flights + 3 Phase II flights = 22 total flights, not 23 as stated in L77
- L78: Rio Grande (RGA), Argentina --> RGA
- L84: Beside --> Besides (or, "in addition to"); also, delete comma after "instruments"
- L108-109: Given the in-flight conditions as described in this paragraph, it makes sense that the mean precisions during the campaign are poorer than those measured in the lab. So it is

puzzling that the mean precisions during the flights improved over those measured beforehand for methyl chloroform. Do the authors have an explanation?

- L108-112: It is stated that for CFC-113 "the amount of water in the analytical system should be kept as low as possible", but it is not clear whether that was actually done during the campaign. The implication is that in fact this was not done properly and that is why the in-flight precision of CFC-113 is so much worse than that determined in the lab, but this point needs to be clarified. I also think it is questionable whether the measurement of CFC-113 really stands out as an "exception" (L108) for its degraded performance. In fact, the precision estimated during the flights is even worse relative to the pre-campaign value (a factor of 5 difference) for CFC-11.
- L109: precision CFC-113 --> precision of CFC-113
- L109: It seems odd to me that the authors make the effort (L85) to define "payload", which is a widely known and not particularly technical term, but not "elutes", which many of their readers (including me) may not know. Also, should it be "CFC-113 is eluted by water" rather than "CFC-113 elutes near water"?
- L110: add a comma between "water" and "the amount of water"
- L111-113: Precision values are not given for GhOST-ECD SF_6 either in the text or in Table 1, yet SF_6 measurements are mentioned later in the paper.
- Table 1 caption: have been determined shortly before the SouthTRAC (ST) campaign and mean precisions during the flights --> have been determined in the laboratory shortly before the SouthTRAC (ST) campaign, and mean precisions were calculated during the flights
- L120: prior --> prior to
- L122: was of --> was
- L123: post-flight corrected --> corrected post-flight

Section 3

- L125: The occurrence of chlorine activation also depends on factors other than temperature (e.g., humidity, the availability of suitable aerosol particles) and has been observed outside the polar regions, so it would be better to say "tends to occur" rather than "occurs" here.
- L129: conclusion --> conclusions
- L134-135: Modern meteorological reanalyses have fairly high resolution these days [e.g., Fujiwara et al., ACP, 2017]; although they still do not resolve very small-scale features, it is not entirely fair to characterize them as having "rather coarse resolution".
- L138-145: This part of the paragraph is poorly written, repetitive, and hard to follow. It should be reorganized to improve the flow.
  - The sentence "It can be measured … atmosphere." is out of place, as it comes in between two sentences that say essentially the same thing. It should be moved and the other two sentences combined to reduce repetition.
  - Not only is the statement "the isolation inside the vortex benefits mixing on isentropic surfaces and therefore a small variability on isentropes (variability of about 6 ppb)" grammatically incorrect, but also it makes no sense. I'm not sure what "benefits mixing" means? Perhaps "inhibits" was meant? In any case, this sentence needs to be rewritten.
  - The sentence "The low mixing ratios inside the vortex … N_2O" again repeats the same information already stated twice above. (Also, descend --> descent)

- the mid-latitudes vertical gradient is weak and more variable --> the vertical gradient in mid-latitude N_2O is weak and more variable

- L146-147: "Towards tropopause altitudes, the N_2O profiles of vortex and mid-latitudes merge and differentiation becomes difficult." Near the tropopause the vortex proper – and the transport barrier it represents – is no longer defined; the region in which chemical processing still takes place but confinement is weak (below ~350–380 K in SH, ~400–450 K in the NH, depending on the year) is often termed the "subvortex" [see Santee et al., JGR 2011, and numerous references therein]. So it is not appropriate to refer to "vortex profiles" in this region.
- L149: at best --> ideally
- L152-153: "Stratospheric transport and mixing is related to the isentropic surfaces whereas mixing at the extratropical tropopause affects the lowest 25 K relative to the local tropopause." This sentence needs work.
  - The wording "is related to" is not clear. I assume that the first half of this sentence is referring to the fact that adiabatic flow in the stratosphere largely occurs along isentropic surfaces, but this should be clarified.
  - is --> are; also, add a comma after "surfaces"
  - References are needed, especially for the point that mixing affects the lowest 25 K above the tropopause (see below).
- flights, which --> flights that; contact to --> contact with
- L155-157: "Data from these flights were pre-filtered by taking only the measurements polewards of 60°S equivalent latitude and 20 K above the local tropopause." There are several issues with this sentence.
  - The concept of equivalent latitude should be defined and a suitable reference for it provided (e.g., Butchart & Remsberg [JAS, 1986]).
  - Presumably the EqL is being calculated based on PV from a meteorological reanalysis, but this information needs to be provided. The reanalysis being used in a study is typically identified in the "Data and Methods" section – here that section is entitled "The SouthTRAC Campaign", but the meteorological data is also an important component of this study and probably merits its own subsection. I have more to say on this point later.
  - Similar to the above point, it needs to be made clear how the local tropopause is being determined. The Fig. 2 and 8 captions mention the "WMO tropopause", but more detailed information should be provided in the main text. In addition, it seems that the results may be highly sensitive to the exact definition of the tropopause used, and some discussion of the associated uncertainty in the results would be appropriate.
  - The Antarctic vortex frequently extends to EqLs lower than 60°S EqL. Have the authors made sure that imposing the 60°S EqL cutoff has not eliminated vortex profiles in 2019?
  - The previous paragraph states that mixing affects the region within 25 K of the tropopause, so it is not clear why the cutoff here was chosen to be 20 K.
- L157-158: This sentence ("The lowest levels …") is repetitive, unnecessary, and out of place – it should be combined with the similar sentence in L152-153.
- Fig. 2 caption: to the local --> from the local; criterion on --> criterion of; the the --> the
- L158-164: One general comment is that the creation of reference profiles is a key point on which much of the following analysis rests, and its description should not be relegated to the separate Supporting Information, which many readers will not make the effort to obtain. I

would prefer to see it in the main text, but it should at least be moved to an Appendix included at the end of the main paper file (unless ACP no longer allows such Appendices). Another general comment is that the main text, SI, and figure captions together fail to clearly describe the method, as specified in more detail in the points below.
  - L160: At this point, the reader has no idea what is meant by the term "vortex profile function." Also, Werner (2006) is a PhD thesis for which no download information is given, and thus it is not a suitable reference.
  - L161: Elsewhere the convention "60°S EqL" is used, so for consistency "-40° and -60° EqL" here should be "40° and 60°S EqL".
  - S1, L2-9: The first two paragraphs of the SI are fully redundant with the discussion in the main text. Apart from this repeated material, the description of the procedure in the SI is only one paragraph long, so again I would argue that it would be better to edit, merge, and rearrange the discussions in S1 L10-28 and L158-164 to produce a single compact paragraph in the body of the paper.
  - Fig. S1: I did not find the flowchart to be particularly helpful, so it could remain in the SI.
  - Fig. S2-S7: It would be much easier on the reader if all of the vortex figures (S2, S4, S6) were combined into one 3-panel figure, and the same for the mid-latitude figures (S3, S5, S7). In fact, it would probably work to combine them all into one 2-row, 3-column figure.
  - S1, L13: is calculated --> are calculated
  - S1, L14 and L21: pre-setted --> preset
  - S1, L14: measurements, which --> measurements that
  - S1, L17: Is this the case --> In this case
  - S1, L21: shows --> show
  - S1, L23: latiudes --> latitude
  - S1, L22-23: More discussion is needed on the 3% and 10% "outlier limits" for vortex and mid-latitude profiles, respectively. How were these preset outlier limits and $\Delta\theta$ bin sizes determined? What factors drove the differences between the values of these quantities for the vortex and mid-latitude profiles? How sensitive are the results to these choices?
  - Fig. S2: What causes the "staircase" pattern between the points discarded in iterations 1 and 2? Also, left over --> leftover, but "remaining" would probably be a better word here (also in the Fig. S3 caption)
- L167: decent --> descent
- L168-169: Greenblatt et al. [2002b] quantifies descent inside the Arctic vortex and thus has only limited applicability for SouthTRAC, since the characteristics and seasonal evolution of descent are somewhat different in the two hemispheres, as discussed by Manney et al. [JAS, 1994], which would be a more appropriate reference. Manney et al. note that parcels in the SH lower stratosphere generally cease to descend in mid-October, so descent might still be ongoing in September, contrary to the statement made here. Also, a further --> further.
- L173-174: I am confused about the "prescribed cutoff value" for vortex profiles and "associated variability" for mid-latitude profiles mentioned here and specified (20 ppb and 15 ppb, respectively) in the Fig. 2 caption. Where did these values come from? Why is one characterized as a "prescribed cutoff" and the other as an "associated variability"? Do these values have anything to do with the outlier limits discussed above? In addition, it seems that all points falling "below" (i.e., to the left of) the grey "cutoff" curve are deemed to be vortex points, even when they are "above" (i.e., to the right of) the black N_2O_{vor} curve, but that is

not what is said in "if the mixing ratio is below the respective N_2O_{vor} with a prescribed cutoff value, then it is assigned to the vortex" (and similarly for the mid-latitude case).

- L176-177: It is stated that measurements in the overlap region cannot be "fully assigned to one region". So what was done with them? Were they included in the analysis or discarded? This question is answered later in section 4.3, but the reader should not be left in suspense here. Also, delete the comma after "ratios", and "cannot" is one word, not two.
- L181: has been --> was
- L183: "timed" sounds intentional, whereas I believe that the campaign fortuitously took place shortly after the SSW. This sentence is also grammatically awkward. I suggest instead: "… November; thus they occurred shortly after the minor SSW event and captured the late winter evolution …"
- L187: Other flights besides the 11 September flight are omitted from Fig. 3, since the number shown does not add up to the total given in section 2.
- L189: It is not quite true that "flights sampled mostly inside the vortex or vortex boundary region" during Phase I – in fact, Fig. 3 shows that few or no such measurements were taken on nearly half of those flights. Also, extensive --> extensively; add a comma after "phase"
- L191: more than half of the … air 54% --> more than half (54%) of the … air

Section 4

- L194-197: These sentences about EESC seem out of place here. Perhaps they would fit better at the beginning of subsection 4.2, or in the Introduction. Also, matter --> manner
- L197-199: These two sentences are redundant with the paragraph at the start of section 4.1. It would be better to merge / edit to avoid such repetition from one paragraph to the next.
- L205-206: Measuring CFC-12 on both the ECD and MS channel of the instrument allows to up-sample the measurements of the organic source gases by using the higher resolved --> Measuring CFC-12 in both the ECD and MS channels of the instrument allows the measurements of the organic source gases to be up-sampled by using the better-resolved
- L206: CFC-12 on --> CFC-12 in; throughout the manuscript (including in figure captions), "measurements on" should be changed to "measurements in"
- L207: but also a better precision than on the MS channel --> but they also have better precision than data from the MS channel
- L209: add a comma after "ratios"
- L209: It might be good to add "linear or polynomial" in front of "fit function".
- S2, L30-31: For up-samling the GhOST-MS measurements, pre-required are good correlations between CFC-12 and the other --> Up-sampling the GhOST-MS measurements requires good correlations between CFC-12 and the other
- Fig. S8: It should be made clear in the caption that all of the data shown are from the GhOST-MS channel. Also, the small font makes the axis labels on these panels very hard to read.
- Fig. 5: In red, original data, whereas is black, measurements were up-sampled using CFC-12 measurements of the ECD channel --> Original data shown in red, measurements up-sampled using CFC-12 from the ECD channel in black
- L216-217: It is not that "the original data were not well captured"; rather, the original lower-resolution data did not capture well the abrupt transitions between regimes.

- L224-225: I find this wording unclear. It would be better to rewrite as: "Organic chlorine (CCl_y) … up-sampled GhOST-MS measurements. Thus, Cl_y can be calculated from Eq. 1 if the mixing ratios of the major chlorine-containing substances at the stratospheric entry point (Cl_{total}) are known. Air enters the stratosphere predominantly …".
- L227: can not --> cannot
- L228: times in the stratosphere since they entered the stratosphere --> times since they entered the stratosphere
- L236: previous --> previously
- L238: ratio, which --> ratio that; degradation and thus --> degradation, which thus
- L239: It would be appropriate to add "estimated" in front of "entry mixing ratios"
- L241: For the case no --> For the case where no; also, to make the distinction between the so-called "semi-direct" and "indirect" methods more clear, it would help to add "indirectly" between "calculated" and "based on".
- L244: add a comma after "trends"
- L246: where --> when
- L247: delete the commas after both "showed" and "tracers"
- L254: respective entry --> respective estimated entry
- L256-257: rations with --> ratios by
- L259: It is difficult for the reader to keep track of exactly what is meant by the "direct", "semi-direct", and "indirect" methods. To help clarify this sentence, it would be good to add "based on previous balloon observations transferred to 2019" after "indirectly determined correlations" (assuming that I am interpreting the approaches correctly).
- L259: indirectly determined values are not only based on observations which have been performed about 10 years earlier but also are from the --> indirectly determined values are based on observations that were not only performed about 10 years earlier but that were also from the
- L261: This wording is unclear. Replace "They" with "The balloon-based correlations".
- Fig. 6: I assume that the SouthTRAC (black) points in this figure show the up-sampled (not raw) GhOST-MS measurements for CFC-11, etc., but this should be stated explicitly. Also, I may not be interpreting this figure correctly. Do the red symbols represent the correlations between balloon CFC-11 (for example) and balloon CFC-12 data, or between balloon CFC-11 (for example) and GhOST-ECD CFC-12 data? Please clarify. In addition, the term "retrended" is used only in the figure caption and legend, not in the main text. Although it is somewhat ambiguous, it is fine to use this term as long as it is defined in the body of the paper.
- L262-265: I am not following the logic here. I understand that a subset of the components of CCl_y "retrended" from earlier balloon data match well correlations with CFC-12 measured by SouthTRAC (Fig. 6). But why does that necessarily mean that CCl_y based on correlations with CFC-12 can be used as a good proxy for Cl_y? I feel that a step is missing. And why is it relevant to mention here again that Cl_{total} can be derived to calculate Cl_y – that information is not being used for Eq. 2 and the indirect method, is it? In general, I feel that the relationship between Eq. 1 (at the heart of the semi-direct approach) and Eq. 2 (the basis of the indirect method) is not clearly explained. Please clarify this discussion.
- L266-267: Since the previous sentences have been discussing balloon-based correlation functions, this sentence about the GhOST-ECD CFC-12 data seems out of place and confusing

to me – maybe it belongs at the end of the following paragraph rather than here, or perhaps I have misunderstood the role of those data in the foregoing discussion, as noted above.

- Table 2: To enhance clarity, it would be good to add "indirectly" in front of "derive".
- Fig. 7: Are the indirect results shown here from the "retrended" balloon data or from SouthTRAC? I assume the former but this should be stated explicitly. And why not show comparisons for both data sets, since you also provide SouthTRAC coefficients in Table 2? Also, in the caption: Indirectly and directly determined … (green and back) and --> Indirectly (green) and directly (black) determined … and
- L275: delete the comma after "Hemisphere"
- L276: Cl_y, where --> Cl_y in cases where
- L277-278: "Since it was possible during SouthTRAC to measure the organic source gases, the Cl_y from the direct measurements was used for further evaluation." In fact, while reading this section I wondered why the authors bothered to pursue the indirect approach when they actually have direct measurements of CCl_y. The discussion of the indirect Cl_y calculation is particularly confusing, and it is not at all clear at this point what value it brings. So it would be helpful to add a pointer to section 4.4, where the indirect method is needed for the comparisons with Cl_y in the Arctic, to better justify the inclusion of this discussion here. In addition, I think that, rather than "Cl_y from the direct measurements", it would be more appropriate to say "Cl_y determined semi-directly from the measurements".
- L279: Another thing that is not clear to me is why the fit coefficients for N_2O are given in Table 2 if they are not being used here at all. On the other hand, several previous studies have used N_2O to derive Cl_y, so I think it might be useful to expand the discussion of the N_2O correlations. An obvious question that arises is: How well does the Cl_y derived from fits with N_2O agree with that based on the correlation with CFC-12, for both the balloon data and SouthTRAC? A figure similar to Fig. 7 could be added for N_2O.
- L284: only measurements were taken, which are polewards of 40° equivalent latitude --> only measurements polewards of 40° equivalent latitude are used
- L287: an air mass --> air mass
- L289-290: It seems to me that it might be better to exclude the measurements in the overlap region from the analysis rather than "double count" them. How many measurements fall into this category, and how would omitting them change the results?
- Fig. 8: I have a number of comments / questions about this figure.
  - It is stated that data are averaged over -40° to -90° – is the filtering of measurements obtained equatorward of 60° equivalent latitude (mentioned in section 3.1) only applied in calculating the vortex reference profile? Please clarify (here and in section 3.1).
  - The colors denoting the different regions have been changed. Previous figures used a consistent set of colors for these classifications, and it would be easier for readers if that same color scheme was used in all figures for which those classifications are relevant.
  - The lack of tick marks on the top and right-hand axes is annoying and makes it difficult to judge the values given in the text. In addition, the tick marks (especially the minor ones) that are present on the bottom and left-hand axes are too small to be easily seen.
  - Why does Cl_{total} vary with altitude?
  - Elsewhere total chlorine was written "Cl_{total}", and that should be the case here too.
  - For consistency with the text, "-90° to -40°" should be "40°–90°S".
  - "mean averaged" is redundant

- L291: the measurements --> the SouthTRAC measurements
- L292: A reference is needed for the AGAGE results.
- L294-295: add commas after “330 and 390 K” and “390 and 400 K”
- L299-300: “at this altitude” – which altitude? Where Cl_y is maximum? Please clarify.
- L301: Accompanying the minor SSW --> As a consequence of the minor SSW
- L301-302: It is not clear that the 16.4 million km^2 value quoted here refers to the maximum daily ozone hole area. Moreover, it is not true that the 2019 hole was “the smallest since its discovery” – other holes in the mid-1980s had smaller maximum daily area values. In any case, rather than quoting this value from the Ozone Watch web site, a better approach would be to reference the Wargan et al. [JGR, 2020] paper (already cited elsewhere in this manuscript); their Fig. 1d puts the area of the 2019 hole into climatological perspective. Perhaps more importantly, it is not clear what the point of these sentences is. Are the authors trying to imply that Cl_y levels in the 2019 vortex played a role in the weak ozone hole that year? Although Cl_y abundances inside the vortex do vary from year to year as discussed previously by Strahan et al. [JGR, 2014], variations in lower stratospheric temperatures are the primary driver of variations in the strength of polar ozone depletion.
- L303: The title of this subsection suggests that the SouthTRAC and PGS comparison focuses on the polar region, but Fig. 10 and associated discussion includes mid-latitudes as well. It may be true that comparison of Cl_y in the Antarctic and Arctic polar vortices has not been done previously, as the authors assert, but it is not the case that no such comparisons have been performed in the midlatitudes. In fact, total column Cl_y (or, rather, $HCl+ClONO_2$) in the NH and SH mid-latitudes (Jungfraujoch and Lauder, respectively) and the trends therein are compared in the Ozone Assessment (e.g., Fig. 1-13 of WMO 2018). It would be good to place their findings into the context of these (and possibly other) midlatitude results.
- L310: A separation --> The separation
- L311: is based on the above mentioned method based on --> is based on the above-mentioned method using
- S3, L34: the vortex and the mid-latitude profile during PGS is needed --> the vortex and the mid-latitude profiles during PGS are needed
- S3, L35: Phase --> phase
- L312-314: As shown in section 4.2, the indirect method … possible, proves to be comparable --> In section 4.2, the indirect method … possible, was shown to provide results comparable to those obtained by the semi-direct method
- L317: I assume that “2019” is a typo and that the same balloon data from 2009 as used for SouthTRAC were again used for PGS?
- S4, L37: Correlations function --> Correlation function
- L319 and L326: Cl_{tot} --> Cl_{total}
- L319-320: This sentence (“The vertical coordinate of the classification was selected according to the displayed vertical coordinate.”) is confusing and, if I understand it correctly, completely unnecessary, as the very next sentence makes clear that the two panels display the results as a function of θ and Δθ. Also, I am curious why both vertical coordinates are shown here but not in Fig. 8. Then in Fig. 10 only the tropopause-relevant coordinate is shown, with the argument that it allows for better comparison of Cl_y in the two hemispheres. It seems to me that it might have made more sense to show both views in Fig. 8, and then use only the tropopause-relevant coordinate in Figs. 9 and 10 for the reasons stated.

- L322: as it was done --> as was done
- L323-325: Several issues arise in this sentence.
  - As I noted above, information about the meteorological data on which this study depends needs to be provided much earlier in the manuscript, ideally in section 2.
  - I was surprised to discover that the analysis is based on NCEP reanalyses. Insufficient information is provided here to identify exactly which NCEP reanalysis is being used (NCEP-NCAR R1, NCEP-DOE R2, CFSR, or CFSv2), but that needs to be specified and the corresponding reference (i.e., published journal article) cited.
  - I have concerns if either NCEP R1 or R2 have been used for this analysis. Although both are still in widespread use, these reanalyses have been shown in several studies, including some recent papers stemming from the SPARC Reanalysis Intercomparison Project (S-RIP), to be unsuitable for most stratospheric studies (as noted in the S-RIP overview paper by Fujiwara et al. [ACP, 2017]).
  - What exactly is meant by "climatological" here? That is, how many years have been considered in the averages? Were the climatological means also calculated over the days covered by the respective campaigns, or are they monthly averages, or …? Are the climatological tropopauses being calculated over 40° to 90° (this latitude range is stated in the caption, but it is not clear exactly what it is referring to)?
- L326-327: "… abundance of total chlorine (Cltot) was lower in the stratosphere from the time of PGS (2015/2016) to the time of SouthTRAC (2019)" – the wording of this sentence is unclear. It should be rewritten to state that the abundance of total chlorine in the stratosphere decreased between the two campaign periods. It is very difficult for the reader to precisely judge the magnitude of this decline from the figure. Is the difference in the estimated PGS and SouthTRAC values of Cl_{total} consistent with expectation given the known decreasing trend in stratospheric chlorine loading? This is a key point.
- L329-330: the SouthTRAC profile increased stronger and values become more than 435 ppt larger than during PGS within the vortex at equal potential temperatures --> the SouthTRAC profile increased more steeply, reaching values more than 435 ppt larger than those during PGS at the same potential temperatures
- L330: Differences become --> Differences are
- L331-332: This sentence ("Inside the vortex … during PGS.") is entirely redundant with the second sentence of this paragraph and should be deleted.
- L332-333: Although close together between 20 and 25 K $\Delta\theta$, the difference of Cl_y increased to 565 ppt at 65 K $\Delta\theta$ --> Although the two Cl_y profiles lie close together between 20 and 25 K $\Delta\theta$, the differences between them increase to 565 ppt at 65 K $\Delta\theta$
- Fig. 9:
  - Again, please add tick marks on the top and right-hand axes.
  - 40° to 90° --> 40° to 90° equivalent latitude
  - Delete "and as a function of potential temperature difference to the local tropopause" in line 3 – this information is provided in the description of panel (b) below.
  - "mean averaged" is redundant
  - SouhTRAC --> SouthTRAC
- L335: the latitude --> the geographic latitude
- L337-338: and better allow for --> and allows for better

- L339-340: It might be interesting to know how many points contribute to each latitude-altitude bin in both hemispheres. Is there a minimum threshold for the number of points in each bin? Perhaps bins with very disparate numbers of points contributing in the NH and the SH could be marked in some manner.
- L341: add a comma after "latitudes"
- L344: Highest levels of Cl_y reach 386 ppt more Cl_y during PGS --> The highest values of Cl_y reached are 386 ppt greater during PGS
- L345: vortex of each hemisphere is --> vortices of the two hemispheres are
- L347: I do not believe that "sporadic", which means "infrequent" or "intermittent", is the right word here, especially as no time information is conveyed in this plot. Perhaps "weak" or "moderate" would work, if I have understood the point the authors wish to make.
- L348: it is not clear what "it" is referring to here -- Cl_y?
- L349: for both --> in both; add a comma after "hemispheres"; there is no need to introduce the acronym for ExTL since it is not used again in the manuscript
- Fig. 10: Please add tick marks on the top and right-hand axes as well as minor tick marks. Also, the color bar label should indicate that these are differences, not raw Cl_y values.

Section 5

- L352: Using an extended method according to Greenblatt --> Extending the method of Greenblatt
- L353-355: It is stated that, compared to coarser-resolution PV, the method to define the vortex used here allows small structures such as filaments to be resolved. First, as noted earlier, modern meteorological reanalyses provide PV at fairly fine resolution. Second, no evidence is presented in this paper that any such filaments were actually resolved using their approach. So I am not convinced that a PV-based definition would not have been adequate.
- L358-360: The authors are correct when they point out that the dynamical tropopause would be more appropriate for this kind of study than the thermal tropopause. Unfortunately, the use of the WMO tropopause raises questions about the value of this investigation. I do not really understand how the authors can say that "no dynamical PV tropopause data is yet available for the SouthTRAC campaign". In fact, high-resolution PV fields are available from multiple reanalyses. There is abundant literature discussing which PV values are most appropriate for defining the dynamical tropopause, depending on the hemisphere and isentropic surface, etc. So it is not clear to me why the authors could not have chosen representative PV values and performed their own interpolations to the in situ measurement locations to determine the local tropopause. But even if the authors are not set up for those calculations, they could still do more to reassure readers that use of the thermal tropopause does not substantially affect their conclusions. Keber et al. used the dynamical (2 PVU) tropopause, so that information is readily available for PGS. Some simple comparisons between the WMO and PV tropopauses for the period of the PGS campaign and examination of the impact the differences between them have for Figs. 9 and 10 would be informative.
- L364: CFC-12 on --> CFC-12 in
- L365: channel --> channels
- L372: add a comma after "SouthTRAC"
- L374: add a comma after "2015/2016"

- L375: “At the time of publication, it is not known that such a comparison has already been made”. First, this statement is somewhat ambiguous. I think the authors mean “To our knowledge, such a comparison has not been published previously.” Second, they should be a bit more precise in the language here, focusing on Cl_y in the polar vortices, given the discussion of mid-latitude Cl_y in the WMO Ozone Assessment as noted above.
- L382: would be negative to about --> are estimated to be negative at about
- L382-383: The difference of Cl_y inside the respective vortex is significant and even larger than the inter annual variations reported by Strahan et al. (2014) --> The differences in Cl_y values inside the two vortices are substantial and even larger than the interannual variations reported by Strahan et al. (2014) for the Antarctic. (See earlier comments on a similar statement in the abstract.)
- L384: of the respective --> in each
- L385: respective campaign only shows a section of the respective winter seasons. These sections do not match --> respective campaigns only show a portion of the winter seasons. These intervals do not correspond
- L386: the respective polar vortex --> the two polar vortices
- L389: add a comma after “SouthTrac”
- L391: First, citations need to be added to support this statement about the BDC being stronger during NH winter than during SH winter. Second, I think it would be more appropriate to move the conjecture about a possible cause for the interhemispheric disparity in Cl_y to section 4.4, where these results are discussed, rather than have it in the “Summary and Conclusions” section. In addition, I’d like to see the discussion of the discrepancy and its possible causes developed a bit more, and put into context of the midlatitude results in WMO 2018 (mentioned above). Also, I suggest some wording changes: on the northern winter hemisphere than in the southern winter hemisphere due to stronger Brewer-Dobson circulation --> during winter in the Northern Hemisphere than during winter in the Southern Hemisphere due to the stronger Brewer-Dobson circulation.
- L393: in higher --> at higher
- L394: exhibits a larger variability as it is more effected --> exhibits larger variability as it is more affected; also, capitalize “Southern Hemisphere”
- L395”: side -- > hand; is less effected --> is typically less affected