

Interactive comment on “Temporal evolution of chlorine and minor species related to ozone depletion observed with ground-based FTIR at Syowa Station, Antarctica and satellites during austral fall to spring in 2007 and 2011” by H. Nakajima et al.

Anonymous Referee #1

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Nakajima et al. investigate the evolution of several trace gases that are important for polar stratospheric chemistry based on measurements and model simulations. Therefore, they use FTIR measurements from Syowa station as well as satellite measurements from different satellite instruments. Additionally, model simulations with a chemistry climate model are used. This is generally an interesting study, but the study lacks of a clear presentation which makes it difficult to judge if the study itself and the results are sound. I would suggest major revisions before the paper can be

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accepted for publication in ACP.

General comments:

1. The title is not really representing what actually has been done in this study. In the title only the FTIR measurements from Syowa are mentioned, but also the satellite observations and model simulations comprise a major part of this study. This should be reflected in the title. I would suggest to simply change the title to: “Temporal evolution of chlorine and minor species related to ozone depletion at Syowa station, Antarctic during austral fall to spring in 2007 and 2011” to be more general or to “Temporal evolution of chlorine and minor species related to ozone depletion from observations and model simulations at Syowa station, Antarctic during austral fall to spring in 2007 and 2011” to be more specific.
2. The content of the Appendices are not that unimportant and therefore I would suggest that these parts are moved to the main text while rather other figures, as e.g. parts of Fig 13-16 could be put into the Appendix (see my comment on these figures below for more details).
3. The discussion section is rather a continuation of the result section. These two subsections should be divided into subsections with subsections header that describe what actually is analysed (time series, correlation etc.)
4. There are too many tables and figures in the current version of the manuscript. These tables/figures could be combined. This would not only reduce the number of figures, but also make the manuscript more concise (see also my specific comments below).

Specific comments:

P2, L6:similar to the case in the Arctic....This needs more explanation and

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maybe also some references.

P2, L13: "...great year-to-year variability." I think this only holds for the Arctic and not for the Antarctic. The distinction between Arctic and Antarctic should be made here and the differences between both regions should be discussed.

P2, L18: References should be added.

P3, L3: Please add which temperatures are needed. Do you mean with the term "inactivation" the "deactivation"?

P3, L15-16: This sentence should be rephrased and maybe even better split into two sentences. It is not clear what you mean here. Also in Antarctica PSCs should occur within the polar vortex. Or is there a shift between the cold area and the vortex? If yes this should be said more clearly. However, you discuss here the temperature, so I guess you just mean that there are less PSCs in the Arctic due to the generally higher temperatures there.

P3, L30ff: Section 3 describes the validation of the FTIR measurements, but in the introduction nothing is mentioned about this validation.

P4, Section2: I would suggest to make two subsections, one for FTIR and one for the satellites and to also extend the description of the satellite data sets since these data sets are not that unimportant for this study.

P4, L5: I would suggest to discuss the discovery of the ozone hole based on the typical papers as e.g. Farman et al., 1985, Nature, first and then to discuss the measurements of the ozone hole over Syowa.

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P4, L23ff: The abbreviations FASATM, CIRA-86, ILAS-II have not been introduced yet. The abbreviations of Aura/MLS and Envisat/MIPAS have been introduced in the abstract, but should be introduced once again here in the main text of the manuscript.

P4, L27ff: O3, HNO3, HCl were used as a priori. What about ClO and ClONO2. Were these also used as a priori?

P5, L5: The abbreviation CALIPSO has not been introduced yet.

P4-5. General: Different satellite instruments were used for different trace gases. It should be motivated why different instruments have been used and it also should be discussed if instrumental differences influence the results. What is the quality of the used data products?

P7, L12ff: A motivation is missing why two years and two altitudes have been considered. So far I could not see that the results are that much different so that it is justified to show two different altitudes and two different years. The differences between these two years and two altitudes need to be more clearly described.

P8, L1ff: As mentioned above the discussion is rather a continuation of the result section. This section should be divided into subsections that describe what actually is analysed (time series, correlations etc.)

P9, L7ff: The comparison to model simulations is not really a comparison. It's rather a different way of analyses of the winter using a different data set than the ones before.

P10, L21-22: "...as there was little NO2 available due to the depleted O3 amount

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here." This needs definitely to be explained. What is the relation between these two species?

P11, 3-4: "This study was (→ were) the first continuous measurement of chlorine species related to the ozone hole from the ground in Antarctica" If this is really the case, then this should be also mentioned in the abstract.

P11, L25-26: "...like the case in the Arctic → like it is the case in the Arctic". That needs more explanation. It has not been stated what the usual case in the Arctic is and what generally the differences between Arctic and Antarctic are.

P11, L26ff: Conclusions should be given.

P11, L26ff: References should be given. The processes and interplay between the species are already known and documented. At statement what actually are the new findings of this specific study is missing.

Appendix A and B: Move this to these parts to the main text.

Tables: Too many tables! I would suggest to combine Table 4 to 9, thus creating a long table. Add a column for the species and then put the current tables under each other.

Figures 2-4: There are also too many figures. Figures 2-4 could be combined by putting these under each other.

Figure 8: Is it really necessary to show here two years? Couldn't one of the years put into the appendix or a supplement to the paper since the results do not seem to be that much different.

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Figure 10: I would suggest to use lines instead of symbols. The interplay between the trace gases would then become much better visible (the same holds for Figure 6-9).

Figures 13-16: Why is a complete different representation of the model results used than for the measurement data? How are these comparable? I would suggest to combine Figures 13-16 and not to show all trace gases, but a selection. Put the gases in the rows and the dates in the columns. The remaining gases could be put into the appendix or a supplement to the paper.

Figures B1 and B2: These figures should be put into the manuscript instead of the appendix.

Technical corrections:

P1, L14: please add "the", so that it reads "understanding of the mechanisms.".

P1, L29: change sentence to: "by reaction of ClO with NO₂".

P2, L19ff: The numbering of the reactions. Doing this differently than just using number as e.g. using R1 to R13 would be more concise. However, how to do the numbering of equations should be checked with the ACP guidelines.

P3, L3: when stratospheric temperature gets warmer → when stratospheric temperatures get warmer

P3, L4: mainly occur → mainly occurs

P3, L9: between in → either "between" or "in", but not both.

P3, L23: Use a different beginning for the sentence as it is done now. Maybe it is even easier to combine this sentence with the one before so that it reads: "... discovery of the ozone hole by direct observations from high-altitude aircraft."

P3, L23ff: If a not complete references list is given because there are too many references, these should be referenced with "e.g." in front and not with "etc." at the end.

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P3, L28: trace components → trace gas components or better to write trace gases
P3, L30: trace species → trace gas species or trace gases
P3, L32: “during the course of the winter” or “during the ozone hole formation and dissipation period”, at least “in the” should be replaced by “during”.
P3, L33: rephrase sentence to “....Finally, distributions of minor species simulated with the MIROC3.2 chemistry-climate model”.
P4, L30: Figures 1(a), (b), and (c) → Figures 1 (a)-(c) .
P5, L11: Same here for Figure 2.
P5, L16ff: Instead of just “D value” it should read “relative difference D” or just “relative difference”.
P5, L26: Figures 4(a) and 4(b) show → Figure 4 shows
P5, L29: the maximum → a maximum
P6, L5: Rephrase sentence to “Figure 5 shows the temporal variation of temperature and chlorine species....”
P6, L7: on the figures → in the figures
P6, L12: temperature → temperatures
P6, L12: are → were
P6, L16: Figures 6,7,8 and 9 → Figures 6-9
P6, L18: MLS in parentheses obsolete since it is written “...observed by Aura/MLS...”
P6; L21: correlation → equation. More correctly it should be written “polynomial equation derived from the correlation of Cly and N₂O”.
P6, L22: Skip “of” and replace the comma by a colon
P7, L12: is → was
P7, L25 and 28: ppb → ppbv
P8, L5: Rephrase sentence to “Figures 10 and 11 show the temporal variation of the ratios of the chlorine species to Cly*” or “Figures 10 and 11 show the temporal variation of the ratios between the chlorine species and Cly*”.
P8, L25: include “the” so that it reads “...with HCl increase, then the ClONO₂ amount gradually.”

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P9, L7: Figures 13, 14, 15, 15 → Figures 13-16
P9, L7: (a), (b), (c), (d), (e), (f) are obsolete.
P9, L16: reaction (12) → Reaction 12
P9, L18: (1), (2), (3), (4) → (1)-(4)
P9, L34: simplify this sentence with listing the trace gases and then adding Figure 16 in parentheses.
P10, L8: comma before “are” obsolete.
P10, L12: comma before through obsolete
P10, L13: At higher latitudes → “At this latitude” or “At latitudes > 87.9”
P10, L14: after → in
P10, L15: enhancement → enhancements
P11, L6: altitude → altitudes
Figure 6 caption: remove (FTIR) and (MLS) and (sonde) since it is enough if this suffix is given in the figure legend. Change last three sentences to “See text for details. The unit of O₃ is ppmv and of the other gases ppbv. The light and dark shaded areas are the days when Syowa station was at the boundary region and outside the polar vortex, respectively.
Figure 8 and 9: The months should be added here as it done for figures 6 and 7.
Figure 12: “day number 220 – 260” → add time period as dates

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