

Interactive comment on “Characteristics and error estimations of stratospheric ozone and ozone-related species over Poker Flat (65° N, 147° W), Alaska observed by a ground-based FTIR spectrometer from 2001 to 2003” by A. Kagawa et al.

A. Kagawa et al.

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We greatly appreciate the referee’s helpful comments and suggestions. We thank the referee for the time to improve our manuscript. We have carefully considered the referee’s comments and will correct our manuscript as much as possible in the revised version. The following are our responses to the referee’s comments.

General comments

1. While the results are compared with respect to the paper of Barret et al. a major topic of this paper has not been considered. Barret et al. used a wide microwindow at 1000 cm⁻¹ to improve the sensitivity and vertical resolution in the troposphere. This reduces the influence of a priori data. It may improve the agreement with other tropospheric data also in this study. Furthermore, a comparison with Schneider et al (ACP, 2005, JQSRT 2005) is missing.

Response: Thank you for your suggestion. Comparison with *Schneider et al.* (ACP, 2005, JQSRT 2005) will be included in the revised version as an important and instructive study for our analysis. Detailed analysis by *Barret et al.* (2002,2003) to improve precision of tropospheric data using wide microwindow will be referred to in the revised version.

2. Cell measurements to derive the ILS are mentioned. But ILS results are not presented. Furthermore, it is not clear whether these results have been used for the analysis of atmospheric spectra.

Response: Result of ILS determination from HBr cell measurements will be shown in the revised version. Information from the HBr cell measurements were used in the analysis. We will include this extra information in the revised version.

3. Data presented are limited to the period of 2001 to 2003. Observations made before and after this period are not included in this study without giving any reason. Discussion of atmospheric topics is quite limited. Maybe it is beyond the scope of this paper. However, a more detailed discussion with respect to the position of the vortex would be also helpful when comparing results with other data sets. Using the presented time series of HF or that of the ratio of HCl to HF might give a hint whether polar air masses have been sampled occasionally.

Response: We included analysis for period from 2001-2003 to report retrievals and error analysis mainly as this report is the first paper that concern stratospheric species

from the Poker Flat site. Detailed discussion of atmospheric topics will appear in the near future. Therefore we agree with the referee's comment that discussion of atmospheric topics is limited in the paper, but for the reasons given above. Concerning the vortex analysis, as we commented to referee 1, we have PV data available for the Poker Flat location using UKMO data. We will include the condition of the polar vortex in the 2001-2003 spring period and have noted the possibility of perturbations to species in the several ten percent range in the revised version. We are looking at additional analysis using HCl and HF as an indication of the proximity of Poker Flat to the Poker Vortex edge.

Specific comments

1. P. 10302 + 10317: "Poker Flat is located between the Arctic region and mid-latitudes. Because it is outside the polar vortex for most of the winter and spring,": On the other hand CO enhancements due to polar intrusions from the mesosphere have been observed in late winter (Kasai et al, 2005). Is polar vortex air sampled by any of the data points presented in the study? Are PV data or PV differences checked for the comparison with other instruments?

Response: As commented to referee 1, PV values larger than $28 [10^{-6} \text{ m}^2 \text{ kg}^{-1} \text{ K s}^{-1}]$ at 475 K occurred 20 % of the time 2001, 2 % in 2002, and 3 % in 2003 in March and April (61 days) over Poker Flat, though the calculation is preliminary. We are now looking at the PV data in detail. We will include the condition of the polar vortex in 2001-2003 spring periods in the revised version.

2. P. 10302: "have been validated with Improved Limb Atmospheric Spectrometer (ILAS) II 15 Data": Better use 'compared with' or 'ILAS data have been validated by FTIR'?

Response: Thank you. This text will be corrected following the suggestion.

3. P. 10303+ 10316: "for 2001, 2002, and 2003, respectively (see Table 2)": Why are observation made before (starting in 1999) and after this period not included in this paper?

Response: We included analysis for a period of 2001-2003 to report mainly the retrieval method and the error analysis as described above. The period was also chosen due to the number and density of measurements. Detailed discussion of atmospheric topics will be appeared in near future.

4. P. 10303: Are detector non-linearities (mainly from MCT detector) considered in the data analysis?

Response: There are known biases in the ozone, HCl and HF results from ~ 0 to ~ 2 %, and from ~ 0 to ~ 4 % in the HNO_3 result at least in the stratospheric columns, and that the analysis procedure excluded any data whose offset exceeded thresholds of 2.5 % for ozone, HCl, and HF, and 5.0 % for HNO_3 .

5. Table 1: Not important, but I'm wondering a bit about the numbering of NDSC filters: Why don't you use 1 for the first one and #2 and #3 for the next ones instead of #2, #3 and #3.5?

Response: Because our filter numbers were named from the approximate central wavelength of the passband of the filters. The numbering scheme we use is one of convenience that more accurately reflects the frequency band of the measurements. This practice, we understand, is also common at other NDAAC sites, but not necessarily all of them.

6. P. 10305: "We used the frequency region of 3051cm^{-1} for ozone": For Ozone several microwindows are suitable which might be fitted simultaneously. In particular, a wide microwindow around 1000cm^{-1} as proposed by B. Barret improves the vertical resolution significantly, in particular for lower altitudes.

Response: We agree with the referee's comment. However, retrievals of stratospheric chemical species are the main topic in this paper which have enough vertical resolution for a ground-based FTS. This can be seen in the degree of freedom for signal (DOFS) for our ozone measurement which indicate values of 3.0–4.0 while *Barret et al.* (2002,2003) reported values of 3.0 and 4.7 for narrow and broad microwindows, respectively. We will include the microwindows that the referee suggested for retrievals of ozone in future studies to improve the DOFS and in particular, the vertical resolution at lower altitudes.

7. P. 10305: "The instrument line shape (ILS) function was obtained from retrieval using spectrum of HBr cell measurement": What are the results from these cell measurements? Are these results used in the retrieval of profiles? EAP (Effective Apodization Parameter) is discussed in the error analysis but not here (retrieval analysis). Is EAP fitted when retrieving profiles or is it fixed?

Response: The result from the HBr cell measurement is used in our retrieval of profiles and the result of ILS derived from HBr measurement will be shown in the revised version. In the profile retrieval analysis the EAP was not fitted.

8. P. 10305: "Monthly profiles of ozone ..." have been used: Did you check the influence of changing a-priori on the time series, in particular on the seasonal variation?

Response: This is an important practice. As we commented to referee 1, the difference between retrievals that used monthly and single a priori profiles was small for ozone in 2002 even for partial columns. We could conclude from this that the influence of monthly a priori on seasonal changes is not significant for all species. However we will explicitly calculate the influence of different a priori's for other species and mention in the revised version.

9. P. 10306: A vertical grid of 2 km is quite coarse in the troposphere.

Response: We agree with the referee's comment. In general the vertical grid should be smaller than the resolution of the measurement, but should also be on a grid fine enough to accurately represent the atmospheric path in terms of the radiative transfer computations. The former and latter considerations have different physical aspects; the resolution of the IR technique is typically around 4 km in the troposphere, whereas the determination of the path that a ray takes through the lower atmosphere requires a much finer grid, from experience around 2 km. In some cases, for example water, a finer grid less than 1 km near the surface might be needed. As the focus of this paper is stratospheric species, we have deemed the vertical grid adequate. In future planned studies of tropospheric species, we will adopt a finer grid in the troposphere.

10. P. 10307 + 10312: "The values are comparable with Barret et al.": For Ozone a better vertical resolution has been achieved in Barret et al. using additional microwindow. See also comment above. The influence of the HALOE climatological profiles would be smaller (p. 10312).

Response: We agree with the referee's comment. We will include the study of *Barret et al.* (2002,2003). Thank you.

11. Chapter 5.3. A detailed error analysis and a comparison with Barret et al is given. A comparison with Schneider et al (ACP, 2005, JQSRT 2005) is missing.

Response: A comparison with *Schneider et al.* (ACP, 2005, JQSRT 2005) was missing. We will include this in the revised version. Thank you.

12. P. 10312: Differences of 50% to sonde data as found in the troposphere are quite large and are larger than those reported by Barret et al. or by Schneider et al.

Response: We agree with the referee about a significant difference in the tropospheric ozone between ozonesonde and the FTS. This difference is related to the choice of

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microwindows, ie, the $3\mu\text{m}$ spectral window has less sensitivity in the troposphere than the spectral window at $10\mu\text{m}$ that *Barret et al.* (2002,2003) used. Sensitivity of ozone in the troposphere will improve if this microwindow is included in retrievals, but this is beyond the scope of this paper.

13. P. 10315: "Overall, the gb-FTS O₃, HCl, and HF stratospheric columns are well correlated": Is a correlation coefficient of 0.54 or 0.65 sufficient for this statement?

Response: As we commented to referee 1, while ozone can be described as well correlated with an R^2 of 0.79, the HCl and HF data need further investigation. We will incorporate FTS averaging kernel smoothing on the HALOE data and compare again the resulting profiles in the revised version for proper comparison.

14. Figs. 1 + 9 are quite small.

Response: Thank you. These figures will be shown with appropriate size in the revised version.

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