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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A UT/LS ozone climatology of the nineteen seventies deduced from the GASP aircraft measurement program" *by* C. Schnadt Poberaj et al.

C. Schnadt Poberaj et al.

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We thank Jennifer Logan for her comments and recommendations which have helped us to significantly improve the manuscript. We will first comment on the major changes that we have performed on the manuscript according to the referees' suggestions. Thereafter, we will respond to the minor comments point by point. We have taken into account all suggestions and issues raised by both referees.

Major issues:
1) Both referees strongly recommend to reduce the length of the manuscript. The anonymous referee suggests to significantly shorten the length by at least a factor of two.

2) Due to the questionable quality of the early ozonesonde data, the anonymous referee suggests to remove the section on the comparison of GASP with ozonesonde data from the manuscript (and to address this issue through validation of sonde by GASP data exclusively in a separate paper).

3) Instead, the anonymous reviewer suggests to focus more strongly on the evaluation of the quality of the GASP ozone data and to implement a thorough uncertainty analysis.

Response to the major issues:
The manuscript text has been shortened by an overall 30%, the number of figures has been reduced to 9. This reduction was achieved by following the anonymous referee's suggestion to remove the section on the comparison with ozonesondes, by rephrasing the remaining parts more concisely, and by removing redundancies. The comparison of GASP with ozonesonde data will be dealt with in a follow-up paper.

However, we were not able to achieve a 50% reduction as we also followed the recommendation of the anomyous referee and the editor to include more detailed information on GASP data quality and QA/QC management. To do this, we have included two more sections on "Quality assurance and quality control (QA/QC) procedures" (Sect. 2.1.2) and the "Internal consistency of GASP ozone measurements" (Sect. 2.1.4). Sec. 2.1.4 discusses two near "simultaneous" flights to gain more quantitative information on the accuracy and precision of the measurements. Three new figures have been added to document the quality of GASP measurements.

Applying the above changes, the first focus of the paper is now on GASP data quality and QA/QC management. The other part of the manuscript deals with discussing the GASP climatology and how it compares to MOZAIC measurements and data in the literature. To enhance the significance of the comparison with MOZAIC data, we now also discuss MOZAIC data in former Sect. 3.1 (now Sect. 4.1).

We have somewhat restructured the manuscript allowing the methodology its own sec-

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tion, and moving the discussion of UT seasonality over the Pacific regions, which was formerly part of the general UT ozone discussion (former Sect. 3.2), to the section on UT ozone over the Pacific Ocean (former Sect. 3.3).

In the following replies to the referee's comments, we have not replied on comments concerning the comparison with ozonesondes since this part has been removed from the manuscript.

Replies to referee's comments

- S1672, lines 9/10: "trends are clearly to be the focus of a follow-up paper, not this one, and this result is hardly discussed."
We have tried to define the purpose of this paper and separation to a follow-up paper on long-term changes more clearly in the Introduction and the introductory paragraph of Section 4.

- S1673, comment on Fig. 6:
The former Fig. 6 (now Fig. 8) has been updated to include flight numbers instead of number of measurements for each grid box.

Reply to "Other comments"

- S1673, third paragraph, comment on referencing:
Citations of the recent WMO/UNEP reports (p3453/22), overview papers on sonde data (p3454/2), and the SPARC report (p3454/8) have been added to the Introduction.

- S1673, p3456:
The paragraph on GASP ozone/ERA40 PV has been shortened and the conclusion sentence ("Ĕ a first indication of the quality of the GASP data Ĕ") has been removed.

- S1674, p3466/8:

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The approximate vertical range (in km from the tropopause) has been added to the text.

- S1674, p3466/19: The statement has been removed.

- S1674, p3467, Section 3.1 (see also reply to anonymous reviewer 2 on Section 3.1): The text and former Fig. 3 (now Fig. 5) have been updated to include a comparison with MOZAIC climatological profiles. In addition, we have added a sentence stating the similarity of the GASP seasonal cycle in comparison with SAGE-II satellite data (Wang et al., 2006) and ozonesonde data (Logan, 1999).

- S1674, p3468/9: The text has been updated.

- S1674, p3469/20:
We agree with the referee that the discussion of the potential reason for differences between GASP and MOZAIC over the Atlantic and Northeast USA during summer has not been satisfying. In fact, GASP data over this region have been sampled predominantly during the year 1978 as can be seen from Table A1. Based on an analysis of GASP measurements, Wozniak (1997) found that ozone was higher towards the end than in the middle of the 1970s which, together with the bias towards the year 1978, may explain the relatively high values in GASP. The text has been changed accordingly.

- S1674, p3475/15:
1) air pollution above California: Indeed the worst pollution above the Los Angeles basin occurs when there is a strong inversion. This inversion is almost continuously present in the basin during summer (e.g., Lu and Turco, 1995). Despite the temperature inversion, the particular topography of the region (the Los Angeles basin is surrounded by high mountains on three sides and opens to the Pacific Ocean to the west and southwest) is prone to mountain venting effects in the presence of intense solar heating. As consequence, upslope mountain thermal winds create a chimney effect that injects pollutants directly into the free troposphere (Lu and Turco, 1995; 1996). Thus, it is possible that polluted boundary layer air also reaches the upper troposphere,

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where the GASP measurements took place. This has been formulated as hypothesis in the text. Of course, a full assessment of the potential connection between PBL smog and high UT ozone concentrations would need further investigations, e.g. using back trajectories. The text has been changed accordingly. 2) ozone gradients across the coast (new Figs. 6 and 9): indeed, the selected colour scale was somewhat misleading as it overemphasized the gradients in springtime. In summer, on the contrary, there are distinct differences between ozone above the eastern Pacific Ocean and the North American continent. In particular, whereas values in large regions over the ocean do consistently stay below 60 ppbv and vary only little, ozone over the continent does not fall below 60 ppbv. The differences presumably reflect a reduced influence of photochemistry in the pristine air masses over the ocean. The average ozone mixing ratios over the Pacific and the coast have been added to the text to clarify the differences. The discussion on ozone gradients has been shifted to Sect. 4.3 (Upper tropospheric ozone in the Pacific region).

- S1676, p3486-3489:
The summary and conclusions have been updated to more concisely summarise the results. In particular, we have tried to focus more on the new results (quality of the GASP data, results over the Pacific Ocean).

Reply to “Minor comments”:

- S1676, p3456/10: Text has been changed according to recommendation.

- S1676, p3460/15:
Yes, we tried to say that we took only a single 1-minute average value within a given 5-minute period in order to be consistent with the normal operating procedure. We have tried to improve the text to clarify the text passage.

- S1676, p3460/23:
It is true that low ozone mixing ratios of a few ppb have been observed in the tropical

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UT. However, in the GASP data, low mixing ratios do not only occur in the tropics, but at all latitudes and during all seasons. Thus, there is a real problem with spuriously low values in the GASP data. Unfortunately, it is not possible to distinguish between true very low mixing ratios and erroneous readings. For this reason, all values below 10 ppbv were removed in the UT, where the choice of cut-off is based on the analysis of ozone probability density functions. The text has been rewritten and now contains the above details.

- S1676, p3461/1:
Data were filtered to exclude STE events (UT O3 > 150 ppbv), as those can bias regional means where sample sizes are small. The idea behind not considering the high UT ozone values was the original plan to publish GASP climatology and long-term changes between GASP and MOZAIC ozone in one manuscript. Rare but extreme values could have flawed our analysis of long-term trends. As we have now split the paper up into a climatology (i.e. the present manuscript) and a long-term change part, we have decided to allow for high UT ozone values in the updated GASP climatology, and will discuss the influences of these extreme values on means/changes in the GASP-MOZAIC follow-up paper where necessary.

- S1676, p3462/20, p3469/2: Text has been changed accordingly.

- S1676, p3463/10:
Text has been changed according to the recommendation of the anonymous referee.

- S1676, p3469/8, S1677, p3469/10: References have been corrected.

- S1677, p3469/17, S1677, p3473/17:
Text has been changed following the recommendation.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 3451, 2007.