

Interactive comment on “Tropospheric ozone climatology over Beijing: analysis of aircraft data from the MOZAIC program” by A. J. Ding et al.

A. J. Ding et al.

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We thank Reviewer #1 for his/her constructive comments.

Response to the Specific Comments by Reviewer #1

The overall effect of the pooled statistical analysis is to provide equal weight to each group regardless of the sample size. This is only an effective approach if each group contains enough measurements to yield a truly representative sample size. I am concerned that the sample sizes of some groups may be inadequate. Ozone is so variable that you need at least 20 profiles in a given month to produce a mean that is reliable within +/- 15 % for the extratropical mid-troposphere, according to: Logan, An analysis of ozonesonde data for the troposphere: Recommendations for testing 3-D models and development of a gridded climatology for tropospheric ozone JGR, 1999.

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In Figure 2 where the data are placed into 36 groups, do all of the groups have at least 20 profiles? If not, can the authors show that the sample size is adequate? To increase the sample size the authors can place the data into 24 groups, for 12 months and just two time periods per day.

Response: Some groups in Figure 2 have less than 20 profiles. To address the reviewer's concern on the size of group, we have reduced the number of groups to 24 (12 months and twice a day) from previous 36, which could meet the recommended sample size by Logan (1999). The statistics in Figure 2 (and 6) are similar for the two ways of grouping. Nevertheless, we will amend the two figures with the results from reduced grouping.

In Figure 3 the pooled plot uses data only between 10:00 and 14:00 LT, while the conventional average appears to use data from all times. If the pooled and conventional method are to be compared then they both need to show data from the same time of day. Otherwise the reader can't tell if the differences between the two are due to the time of day or the averaging method.

Response: We agree with this comment. The suggested daytime profiles using conventional method have been calculated, which shows a rather similar vertical profile but the pooled one gives a larger statistical significance. We will add this result to figure 3.

It does seem plausible that the agricultural fires in the NCPs were the cause of the increased column NO₂ above the Beijing region during June. But to be more convincing the authors need to estimate the quantity of NO_x produced from the fires using standard NO_x emission factors for biomass burning and estimates of the area burned. Are the fire emissions significant in comparison to anthropogenic emissions?

Response: We have made an estimate of the relative contribution from biomass burning by comparing the total NO₂ column over Beijing in June (with active fires) and the average NO₂ over May and July (with fewer fires), assuming a same anthropogenic emission of NO₂ in these months. The result suggests that biomass burning con-

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tributes about 20% of the NO₂ column in June over Beijing, indicating an important contribution from biomass burning. We will add this estimate in our revised paper.

Page 9807 What is the rationale for only running back trajectories for “fine weather conditions” based on the absence of rainfall? Is there some reason to believe that the trajectories are less accurate if they are released under poor weather conditions? I don’t think this is the case and I don’t think the authors should bias there analysis away from poor weather conditions. Trajectories should be analyzed for all weather conditions.

Response: As our analysis concerned daytime ozone, our original intention was to focus on days with fine weather conditions to avoid the influence of different photo-chemical situations. To address the above point raised by the reviewer and also to increase profile numbers (as suggested by Reviewer #2), we have included all trajectories during 1995-2005 and re-calculated the results shown in Figure 10. The result on the vertical distribution of different air masses is similar for the two methods. We will use results with all trajectories in the revised paper.

Page 9808 The authors try to explain the high ozone mixing ratios associated with the westerly trajectories as being influenced by air that originated south of Beijing and was then lofted into the mid-troposphere by orographic lifting. But if this were the case, and if the trajectories are reliable, wouldn’t this transport pathway be revealed by the trajectories? It appears that this is not the case and the 3 km trajectories indicate rapid transport from the west with no influence from the NCPs south of Beijing. The authors need to suggest another explanation for the high ozone values.

Response: The westerly trajectories in mid-/lower- free troposphere contained higher O₃ concentrations. These trajectories often originated from lower altitudes and were often associated with southerly flow in PBL in NCPs. A comparison of ozone profiles for Category W and N (from recalculated results) suggests a larger difference exists in lower altitudes, which suggests that the elevated ozone should be related to surface

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sources rather than the large scale background, Based on these observations and the presence of mountains (generally with topographical heights of 2–3km a.s.l) in the west, we propose a possible mechanism that explains the elevated O₃ in the westerlies, that is, the polluted air masses from the south were lifted by mountains in the west to the lower troposphere and mixed with the westerlies before transporting to over Beijing. Although the trajectories do not indicate such a transport pattern, it is possible that the large-scale trajectories used in this study cannot resolve vertical mixing processes. Streamline maps in Figure 8 also shows a belt of convergence of wind flow from the west and the south in western mountainous regions. We will elaborate these points in the revised manuscript.

In the conclusions (and on page 9808) the authors state that the broad mid-tropospheric ozone enhancement during summer could be due to stratosphere troposphere exchange but don't provide any evidence for this in the paper. These speculative statements need to be removed or the authors need to provide evidence. The authors also suggest that biomass burning in Asia could be responsible for the summertime ozone peak. But this feature is seen at many locations at mid-latitudes, so couldn't it be that the mid-tropospheric air above Beijing in summer is just reflecting the overall mid-latitude cycle of mid-tropospheric ozone?

Response: As we do not have sufficient evidence on the source of mid-tropospheric ozone over , we will remove this sentence in the conclusion, and shorten the relevant discussions in the main body..

The standard of English is fairly good but there are many instances of grammatical mistakes or awkward phrasing, too many for me to point out in this review. The authors should work with a colleague (or ACP editor) with excellent English skills to revise the text.

Response: The paper had been edited by a native English editor prior to the submission to ACPD, We will try to polish the revised manuscript.

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Response to Technical comments by Reviewer #1

The font sizes in Figures 1, 4, 5, 7, and 9 need to be increased.

Response: Agree, will increase the figure size.

Abstract line 16 delete “sources”

Response: Taken.

Page 9797 line 11 change to “tropospheric O3 in China”

Response: Taken.

Page 9799 line 5 Saying that MOZAIC makes measurements regularly all over the world is an overstatement. MOZAIC does not fly to or over Australia, the Pacific Ocean, the South Atlantic or the Indian Ocean. Furthermore, the flights do not regularly visit all locations. In fact many locations are only visited in certain seasons, or were sampled during the early MOZAIC years but are not sampled now. A more accurate statement would be that the 5 (now 3) MOZAIC aircraft make near-daily flights between Europe and a variety of destinations throughout the world.

Response: We will modify wordings to adopt this point.

Page 9797 line 14 Do you mean reprocessed instead of reproduced?

Response: “reprocessed” is right.

Page 9801 line 2 What are the vertical and temporal resolutions of the FNL data? Are you just using analyses? State that this is a global model.

Response: Horizontal resolution: ~190 km, vertical: 13 lvls, temporal resolution: 6-hour average. We use the formatted data processed by ARL of NOAA. We will include the information in the revision.

Page 9806 line 12 and the caption of Figure 8 change “wind streams” to “streamlines”

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Response: Taken.

Page 9806 line 19 change “subtropic High” to “the subtropical high”

Response: Taken.

Page 9808 line 1 change “west-coming” to “westerly”

Response: Taken.

Figure 10 Why are the lines solid in some places and dotted in other places?

Response: Dashed line is the result that was averaged from those calculations based on cluster analysis with trajectories ending at different levels. (For example, for altitude 4 km, the result is an average of based on trajectories ending at 3 km and 5 km). We include this note in the figure caption.

Page 9808 line 9 The origin of the elevated ozone in the mid-troposphere is very uncertain and this sentence needs to reflect the uncertainty. It should be reworded to: “but may be due to transport of biomass burning”

Response: Agree, will modify the relevant sentence.

Page 9808 line 22 China is not a subcontinent. This sentence should read: “....trend of O3 in China.”

Response: Taken.

Page 9809 lines 4 and 6 use the term “annual rate of change”

Response: Taken.

In Figure 13 the NO₂ data are presented such that it appears that the Beijing and NCPs NO₂ values are from mutually exclusive regions and can simply be added together. But from the description in the text it appears that some the 1x1 degree box around Beijing may overlap part of the NCPs box, which would then lead to counting some NO₂ values more than once. Are the two regions mutually exclusive?

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Response: We apologize that the previous Figure 13 causes some mis-understanding. The two columns aren't "added together" but should be presented as "columns to zero". We change this figure in the revision. The two regions are not mutually exclusive, Beijing is only a very small part compared to the whole NCPs we defined.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 9795, 2007.

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