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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Surface ozone at the Caucasian site Kislovodsk High Mountain Station and the Swiss Alpine site Jungfraujoch: data analysis and trends (1990–2006)" *by* O. A. Tarasova et al.

Anonymous Referee #1

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General Comments: This paper focuses on the investigation of the surface ozone seasonal cycles and trends at two high mountain stations, one in Russia and the other in Switzerland over the recent period 1990-2006. The trend analysis is applied for two different periods, the 1991-2001 and the recent 1997-2006 in order to unravel the role of changing emissions. I think the paper deserves publication but I have a few points that the authors should consider carefully before the final acceptance of the manuscript.

Major comments:

1) Page 911, line 21: The authors used a level of 650 hPa for JFJ in the their backward trajectory calculations. They should also specify the altitude of the topography for the respective grid point in their trajectory calculations. I guess much higher than 650 hPa. This means that 650 hPa is not at surface but well above surface and hence the PBL influence is significantly reduced in their calculations. The authors should commend on this important issue which similarly applies for Kislovodsk.

2) Page 915, lines 16-18: “The presence of two maxima … of ozone concentration.” What do the authors mean with “existence of the two typical regimes of ozone concentration” ? For JFJ especially, this two maxima distribution can be attributed to different processes e.g. tropospheric ozone production versus stratospheric ozone contribution from STE or NW winds versus SE winds due to the well-known JFJ wind channeling effect (see Schuepbach et al., JGR, 2001).

3) Page 916, lines 2-5: The authors claim that mount venting at JFJ occurs from March to August. Based on studies using aerosol and specific humidity data I have the impression that the mount venting at JFJ due to thermal convection is mainly activated from May to September maximizing in July-August. March and April are not really months that thermal convection is active at JFJ. The authors should commend on that.

4) Section 3.3.1, Page 920: The FT trends with P$<$400 hPa at KHMS are more negative than PBL trends. How does that fit with justification 1) “quite substantial impact of the PBL on the ozone levels at KHMS (especially in summer with developed convection over the continent, hiding the effects of ozone increase at the higher levels in the troposphere) ?

5) Section 3.3.2: The authors report on clear positive trends at JFJ for the earlier period 1991-2001. Why the year 1990 is excluded from this earlier period? Is this simply because the ozone levels in 1990 are a bit higher than in the years 1991, 1992 and 1993 (according to Figure 2a)? Mind please that there is an earlier study investigating homogeneities and trends of the ozone record at JFJ from 1988 to 1996 where a shift

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discontinuity was found in 1991 (see Zanis et al., Atmospheric Environment, 1999). Furthermore there are earlier studies on the seasonality and trends for JFJ which are not cited. See for example: Bronnimann et al., Atmospheric Environment, 2000.

6) There are a number of statements which are too speculative e.g. i. Page 921: “On average the most negative trend is observed (among the most contributing clusters) in the cluster 4, covering the Southern and Central Europe and originating over Central Atlantic. This may be connected with ozone decrease downwind of the area (Central and Southern Europe) with strong emissions regulations of ozone precursors. Similar negative trends are found in cluster 5 (−0.89 ppb/year), which originates over Central Europe, confirming the idea that negative trends at KHMS may be connected not only with local emissions decrease (see below) but also can be impacted by the air advection from Europe.”

ii. Page 922: “In summer cluster 3 is the most frequent one and ozone trends in this cluster are attributable to the decrease of ozone precursor’s emissions of the local scale. Summer trends in the clusters 5 and cluster 4 might be impacted by Southern and Western European emissions decrease due to legislation.”

If the trends in summer cluster 3 shows only the effect of local scale emissions then it would be sensible to assume positive ozone trend in winter due to reduced titration.

iii. Page 923: “Taking into consideration that ozone source areas for KHMS are situated much lower than for JFJ, the shape of the trends seasonality (slight negative trend in winter and slight positive trend in summer might be the signs of the increased ozone production in the PBL over the Atlantic due to ship emission increase.”

iv. Page 925: “The trends remain mostly positive and statistically significant is winter, unlike the other seasons. The only FT subset where trend remains positive and statistically significant in summer corresponds to the cases with “p$<$400 hPa”, i.e. for the air which travels quite high but not necessarily had contact with the stratosphere. The cases which fulfill this criterion may correspond to the long-

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range transport of precursors and ozone from Asia.”

7) Page 924, lines 13-15: The authors state that “Ozone increase in winter is consistent with the ozone response to NO emissions reduction as expected from air pollutants abatement regulation (less titration of ozone in winter and less production in summer).” In spring we have also strong positive trends (0.83 ppbv/year) which are only slightly lower than in winter (0.92 ppbv/year) and possibly not statistically different from winter. Is the justification of ozone titration for winter holds also for spring trends?

8) Page 925, lines 4-8: The authors state “Therefore we can conclude that for the period 1991–2001 the trends at JFJ may mainly be caused by two factors, namely in situ emissions regulations, causing ozone decrease in summer and increase in winter in PBL overlapping with systematic increase due to the growth of the stratospheric contribution (mostly seen in spring). ” However, still we have (Table 7) a strong positive trend for PBL cases in summer (0.76 ppbv/year) which is of similar magnitude with FT/ST ozone trends (0.72 ppbv/year). How that fits with their conclusion?

9) Figure 6: The clusters 1, 3 and 5 seem to be very similar for the case of JFJ while clusters 1 and 6 are also similar for the Kislovodsk. What does it make them different?

10) Figure 9: I think in Figures 9a and 9c it should be P$<$400 hPa.

Minor comments Page 909, lines 5-7: “Among the … by several authors.” Please rephrase or re-arrange the syntaxes of the sentence.

Page 910, lines 25-27: “Jungfraujoch is situated … in spring and autumn (Zellweger et al., 2003; Henne et al., 2005).” These references are fine but there are much earlier references having similar results. For example see Baltensperger et al., JGR, 1997; Lugauer et al., Tellus, 1998.

Page 911, lines 8-10 : “All ozone subsets … respective station.”

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The meaning of the sentence is not very clear. Do the authors mean that they have applied a centered 5-hours running mean?

Page 912: Please add a sentence commending on the differences of the 4 different criteria on the selected FT/ST cases.

Page 917, lines 19-21: “The only … measuring site.” The sentence should be rephrased.

Page 917, line 22: The authors state that the highest ozone in the lower stratosphere occurs in May. I do no think that this true. The highest stratospheric ozone values occur earlier in March-April.

Page 919, line 19: I would suggest “… summer while minimum negative trends” instead of “… summer and minimum negative trends”

Page 921, lines 19-21: What do the authors mean “on average the most negative trend is observed in cluster 4. It needs clarification.

Page 923, line 16:“ (slight negative trend in winter and slight positive trend in summer might …” I guess there is a parenthesis missing after “in summer”.

Page 924, line 8: It should “be sampled over Atlantic” instead of “b sampled over Atlantic”

Page 922, lines 21-26: “ Interesting to note … for considered clusters.” It is difficult to understand the meaning of the sentence. I suggest to rephrase it.

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