Atmospheric
Chemistry
and Physics

Open Access

Discussions

EGU

ACPD

Interactive
comment

Interactive comment on "**Inter-annual variability of surface ozone at coastal (Dumont d'Urville, 2004–2014) and inland (Concordia, 2007–2014) sites in East Antarctica**" *by* **M. Legrand et al.**

M. Legrand et al.

Michel.LEGRAND@lgge.obs.ujf-grenoble.fr

Received and published: 26 May 2016

REV3: General Comments: This manuscript provides a nice synopsis of multi-year surface ozone records at two Antarctic locations: almost 8 years at the inland Concordia Station, and almost 11 years at the coastal Dumont d'Urville Station. A comparative analysis is presented between these stations, South Pole, Syowa, Neumayer and Halley, and the role of various factors influencing the characteristics of the annual and diurnal cycles of surface ozone, such as topography, meteorology, proximity to the ocean, and oxidant chemistry, is examined. With several relatively minor adjustments, this manuscript will be appropriate for publication in ACP. The most significant issue I would like to see addressed is analysis presented in section 3.1.1. on the relationship

between trajectories and ozone concentrations. This is rather unsatisfying, since it is based on a "pick and choose" approach instead of the analysis of patterns that can be rigorously generalized. It also places more trust in trajectory models than they probably deserve, particularly beyond 4-5 days out. I took the liberty of plotting the data in the first two columns of Table 1 (see attached figure). There is no need for me to expand on this plot, since it says everything that needs to be said. It is of course true that there appear to be some correlations in Fig. 4 if some periods are inspected in isolation, but this method is scientifically not terribly convincing.

AUT:Thank you for this comment: indeed Table 1 was not very convincing since everything was smoothed when averaged over one month or half a month. So we remove it and instead we simply plotted all backward trajectories for December (over the 7-8 years of the record) as a function of the corresponding ozone range. This figure far better illustrates the importance of the transport.

REV3:An analysis along the lines of what was presented in Bottenheim and Chan (2006) may, at least partially, alleviate these concerns. With 8 and 11 years of data, there should be enough material here that this type of analysis would provide further insights.

AUT:That is indeed another possibility but we think that this would be less straightforward in Antarctica than in the case of Arctic. Anyway with the figure of backward trajectories introduced in the new version, the role of transport is clearly seen.

REV3:Specific Comments: Page 1 Line 24: cycles: Done P1L26: but not at the South Pole, and a ... This sentence needs to be rephrased. Do you mean "far better mixed layer with higher ozone concentrations"? Also, the 250m needs to be reconciled with numbers in section 4.

AUT:This long sentence was reworded into two sentences as follows: "However, in summer the diurnal cycle of ozone is different at the two sites with a drop of ozone in the afternoon at Concordia but not at the South Pole. The vertical distribution of ozone

above the snow surface also differs. When present, the ozone rich layer located near the ground is better mixed and deeper at Concordia (up to 400 m) than at the South Pole during sunlight hours."

REV3: P2L5: research; separate the effect AUT: Done

REV3: P2L15: remove "that" AUT: Done

REV3: P2L22: (Crawford... AUT: Done

REV3: P3L18: papers in AUT: Done

REV3: P3L32: at DDU AUT: Done

REV3: P4L1: were made once a month AUT: Done

REV3: P4L21: treat McClure et al like any other reference: just give the authors and date, the rest goes to the end of the paper AUT: Done

REV3: P4L28: prior to AUT: Done

REV3: P4L31: the upward shift: if the delay time is predictable, then the shift can be corrected. Was this done to finalize the data?

AUT: As mentioned in the text the shift is variable from one flight to another flight but never exceeded 20 m. The effect remains weak for the cases discussed in section 3.1.2.

REV3: P4L33: This permitted the documentation of the ... P5L2: proved AUT: Done

REV3: Section 2 should also briefly explain SAOZ (which is used in Table 1 but never spelled out until the Acknowledgements).

AUT: OK, since Table 1 was removed following the major issue rise at the beginning of your review, and following the recommendation of the other reviewer to reduce the discussion in Section 6 (restricting the discussion on summer trends to the South Pole) the SAOZ data at Concordia are not anymore needed.

REV3: And it needs to include some details on the trajectory model used. These models are not absolute, and some are better than others. 5 days out, most of them have rather large uncertainties.

AUT: Right and we add a paragraph at the end of section 2 as follows: "To characterize the origin of air masses reaching the DDU and Concordia regions, five day backward trajectories were computed using the Hybrid Single-Particle Lagrangian Integrated Trajectory model (R. R. Draxler and G. D. Rolph, NOAA Air Resources Laboratory, Silver Spring, Maryland, 2003, available at http://www. arl.noaa.gov/ready/hysplit4.html). Meteorological data from Global Data Assimilation Process (available at ftp://arlftp. arlhq.noaa.gov/pub/archives/gdas1) were used as input, and the model was run every 6 h in backward mode for three different altitudes (0, 250, and 500 m agl)."

REV3:I think p.6 can be shortened to one paragraph, and table 1 should be eliminated, because it does not provide convincing evidence of any patterns, even if the patterns the authors strain to see make physical sense.

AUT: Thank you for this comment. We agree and discarded this Table (including the SAOZ values now not discussed in section 6). Instead, we report traces of backward trajectories for the month of December (2007 to 2014) (a new figure, Fig. 6 has been introduced) to generalize the role of the transport on ozone values as also shown in the Figure 4 and 5 (but for specific time periods). The text was updated as follows: "Even on the monthly scale, during the summer the influence of the air mass trajectory on ozone levels is still visible. For instance, as seen in Fig. 6 for December, the highest ozone values (higher than 38 ppbv) correspond to the shortest trajectories that almost always spent a significant time fraction over the highest part of the plateau (above 3500 m asl). Trajectories corresponding to ozone values ranging between 32 and 38 ppbv travelled mostly above 2500 m asl in the inner part of the continent. Finally, ozone values below 26 ppbv are observed when the trajectories were among the longest, sometimes starting from coastal regions or from the ocean (Fig. 6)."

REV3: P7L10: invariant instead of "not modified". AUT: Done

REV3: P7L26: remove "neutral"; convective conditions would conceivably also produce a straight profile Right, AUT: Done

REV3: P8L1: no longer AUT: Done

REV3: P8L2: generally several hundreds of m deep as seen... AUT: Done

REV3: P8L7: radiation AUT: Done

REV3: P8L32: Details AUT: Done

REV3: P9L6: remove "very" AUT: Done

REV3: P9L17: dependent AUT: Done

REV3: P8L23: lasted to the AUT: Done

REV3: P9L30: remove "over" AUT: Done

REV3: P10L19: absence of detectable increase: what about the potential role of meteorology / mixing?

AUT: Yes that is possible but we cannot address this point (as we did for Concordia) since deploying tethered balloons is far more complicated at DDU compared to Concordia (more wind and turbulent regime).

REV3: Also, I suspect the diurnal cycle of O3 at Concordia isn't always as nice as that shown in Fig. 7.

AUT: You are right and this was explained at the beginning of section 3.1.2: only under very specific conditions is a diurnal cycle: "Given the importance of synoptic transport conditions on the day-to-day ozone variability (Sect. 3.1.1), the detection of an ozone trend over several days to estimate a mean local ozone production rate requires the search for a period of several days over which the transport pattern was invariant. As seen in Fig. 5a, from 27 to 30 November 2009 backward trajectories indicate transport

of air masses consistently from the high Antarctic plateau (100% of time above 3200 m asl), and over these 4 days surface wind direction remained unchanged (Fig. 8).

REV3: P11L5: radiation... acts AUT: Done

REV3: P11L9: dynamics AUT: Done

REV3: P11L27: the "always" seems to contradict the statement in L19 about 25% of profiles not having significant vertical gradients;

AUT: No since in fact here we are discussing the cases (75%) when a vertical gradient is present.

REV3: P13L5: remove the "of"s AUT: Done

REV3: P14L20: On the other hand, AUT: Done

REV3: P15L7: of diurnal, AUT: Done

REV3: P15L8: which are, AUT: Done

REV3: P15l15: On the other hand, AUT: Done

REV3: The Conclusions should also mention the winter trend. This is interesting as well.

AUT: Right and we added "Finally, the DDU data indicate a significant increasing trend in winter, motivating the extension of time series in view to examine the possible influence of stratosphere-troposphere transport for instance."

REV3: Table 1: should be removed (see comments above). If you really wish to keep it, you need to discuss the SAOZ column somewhere in the text (which is currently not the case), and explain the colour code (red/blue/black numbers).

AUT: As explained above we follow your suggestion to remove this Table. We also discard from the discussion the SAOZ data to shorten the discussions in Sect. 6.

REV3: Table 2: use standard exponential notation: AUT: OK Done

REV3: Table 3: give the heights in "agl" please, so they can be related to what's in the text: AUT: OK Done

REV3: Fig. 4: identify the interesting episodes discussed in the text with arrows: AUT: Done

REV3: Fig. 10: a grey arrow is mentioned in the caption, but I can' find it.

AUT: Thank you for this remark, in fact the caption was wrong. We now add arrows to highlight episodes discussed in the text.

REV3: Fig. 14: give a definition of the error bars in the caption:

AUT: Done, Vertical bars refer to standard errors of the regression lines.