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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Annual cycle of ozone at and above the tropical tropopause: observations versus simulations with the Chemical Model of the Stratosphere (CLaMS)" *by* P. Konopka et al.

Anonymous Referee #2

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The paper by Konopka deals with an investigation using the CLAMS model of the relative contributions of vertical transport, advection and photochemistry to the seasonal variation of ozone in the Tropical Transition Layer (TTL) reported by the SHADOZ sondes and HALOE. In contrast to previous analysis suggesting only the signature of the seasonal variation of upwelling, it is concluded at a significant contribution of advection from the mid-latitudes and particularly from the enhanced equatorward transport in the summer driven by the Asian monsoon anticyclone in the upper troposphere.

General comments Though the idea of a contribution of meridional transport to the seasonal variation of ozone, ignored in previous studies, deserves consideration, I think that the paper fails to convince that it is significant. There are several reasons for that.

a) Vertical velocity. Given its large vertical gradient in the tropical lower stratosphere, the ozone concentration is extremely sensitive to small vertical displacements. Within a gradient of 80 ppbv / km, a shift of 300 m only would be enough for explaining the observed 25 ppb (20%) amplitude of the ozone seasonal variation at 380K. Even ignoring the possible impact of convective overshooting for which more and more evidence is available, a difference of upwelling of 0.2K /day at this level, like that between the CLAMS model and other estimates (e.g. Yang et al., JGR 2008) would be enough to explain an ozone change of this amplitude within one month.

b) Zonal modulation. As shown in Fig.4, the average zonal wind velocity at the equator at 380K is <10m/s, meaning that it will take about one and half month for an air mass to circumnavigate around the world. If a zonally varying process such as the Asian monsoon or land convection would be responsible for the ozone seasonal cycle, this should translate into phase shifts between the ozone maxima at different SHADOZ stations. This is indeed what it is shown in the plot of the ozone measurements at several stations by Randel et al. (2007) displaying shifts of up to two months between the ozone maxima, although unfortunately the longitude of the stations is not given. I would suggest the authors to look at such possible shifts after providing the location of the 7 stations used in the current analysis.

c) Vertical structure of the annual cycle. Randel et al. found a peak amplitude of the seasonal cycle of 80 ppb (40%) at 17.5 km, decreasing rapidly above. The current analysis of the SHADOZ stations at theta levels (Fig 5) shows a reduced peak amplitude of about 40 ppb (25%) at 400 K decreasing also at higher altitude, consistent with the previous analysis at pressure levels. Compared to this the CLAMS corrected simulation is displaying a seasonal modulation of amplitude significantly larger than the observations at all levels, 70 ppt at 400K, 100 ppt at 420K. Possible reasons for this amplification should be explored.

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d) Meridional exchange. The ozone distribution at 380 K derived from the MLS measurements at 100 hPa, does provide indeed evidence of an influence of advection from mid-latitude alternatively in the northern and southern hemisphere summer, reasonably well captured by the CLAMS, although of larger amplitude. This is for my point of view the best evidence of a possible contribution of meridional advection, It shows a zonal modulation in the ozone distribution at $\pm$ 10° lat which should appear in the SHADOZ stations. It would be also very informative to look at other MLS levels (eg 68 and 47 hPa) to see how high the advection expands in the observations and in the model. Indeed, though I have no information on the northern hemisphere summer monsoon, the meridional exchange at the southern tropics during the local summer is showing a maximum at 14-15 km (350K), of rapidly decreasing amplitude at higher altitude (Borchi et al, ACP 2007).

Conclusions and recommendations The suggestion of a significant contribution of advection from mi-latitude to the seasonal cycle of ozone and other species in the lower stratosphere is an interesting one. But the authors should recognise that the current uncertainty on the vertical transport in this altitude range, as illustrated by totally different pictures provided by the “reference” and “corrected” simulations, do not allow quantifying properly this contribution from a model only. My recommendation would be to encourage the authors to continue exploring the impact of meridional advection. I could suggest to use the MLS and SHADOZ data at different altitudes in the TTL, if possible on a larger vertical range, eg from 147 to 46 hPa, for evaluating the altitude and zonal dependences of the impact of advection and explore the reasons for differences with the CLAMS model.

I understand that this will require major revisions, but I can’t see how doing this otherwise.

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