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Interactive Comment

Interactive comment on "On the hiatus in the acceleration of tropical upwelling since the beginning of the 21st century" *by* J. Aschmann et al.

Anonymous Referee #1

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General comment:

This paper by Aschmann et al. assesses a potential hiatus in tropical upwelling in the lower stratosphere after the year 2002, based on analysis of ozone column (17–21 km) timeseries from satellite observations and CTM simulation. The analysis shows a clear change in ozone trends around 2002, with decreasing tropical ozone column before 2002 and a very weak positive trend afterwards. Further analysis of diabatic heating and vertical upward mass flux in the tropics shows a similar trend change, with an increase in upwelling only before 2002. The authors link the trend change in ozone to the trend change in upwelling and conclude that there has been a hiatus in the increase of tropical upwelling in the first decade of the 21st century.

I think this is a very interesting study addressing the causes for the observed decadal variability in atmospheric composition, a highly relevant topic of current atmosphere and climate sciences. Understanding this decadal variability is crucial to understand and correctly attribute climate change. The paper is clerly structured and well written and I consider it appropriate for publication in ACP. However, the presented link of observed ozone changes to a change in tropical upwelling seems oversimplified to me, and I have two major comments (specific comments 1 & 2), and a few minor comments, which need to be thoroughly addressed, or at least critically discussed.

Specific comments:

1) Structural change of BDC:

My first major comment concerns a potential change in the structure of the BDC after the year 2000, as has been recently discussed by Boenisch et al. (2011), who argued for an increase in only the shallow circulation branch. The transition region between the shallow and deep branches of the BDC is located exactly within the 17–21 km layer considered by Aschmann et al. Hence, from the perspective of such a structural change the weakening tropical upward mass flux across 70 hPa after the year 2002 (see Fig. 4) is not necessarily in contradiction to a continued increase in tropical upwelling, if only the shallow circulation branch is strengthening. Further, if the ozone partial column between 17–21 km is dominated by the upper levels (what is very likely due to the strong increase of tropical ozone with altitude), the related ozone response could likely show the observed decrease before 2002 and a hiatus of this decrease afterwards.

Therefore, linking the trends of ozone partial columns as well as of mass flux across

ACPD
14, C2374–C2378, 2014

Interactive Comment

70 hPa to changes in tropical upwelling in general, seems oversimplified to me. I think it could be beneficial for this study to separate the effects of changes in the shallow and deep circulation branches, to clarify whether a general weakening or a structural change in the circulation has occurred. A simple step into this direction could be to consider different levels and to infer the shallow branch from the difference, similar to the study by Lin and Fu (2013).

2) Impact of mixing on tropical ozone:

My second major comment addresses the impact of horizontal mixing with mid-latitudes across the subtropical mixing barrier on tropical ozone. Such mixing transports ozone-rich mid-latitude air into the tropics and is not a 'secondary effect' (P9953/L15), as first shown by Konopka et al. (2009). The controversal debate about the impact of such in-mixing has been reconciled in the recent paper by Abalos et al. (2013). At levels of about 17–18 km about 50% of tropical ozone during summer has been in-mixed from mid-latitudes, and even at 21 km this fraction amounts to 20% (Abalos et al., 2013, Fig. 4b), although the mixing itself becomes very weak above the TTL.

Consequently, a slight trend in mixing, even if occurring below the considered layer, could likely have a significant impact on the partial ozone column between 17–21 km. Hence, linking the tropical ozone trend to upwelling without taking mixing into account seems problematic to me. If the mixing effect could be diagnosed within the model, this could 'proof' the dominant role of upwelling in causing the ozone trend - or shed more light on a potential additionnal role of mixing. At least a critical discussion is needed to make the reader aware of this source of uncertainty in the analysis.

P9955, L11:
Is there a particular reason to use all-sky and not the total diabatic heating rate from

ACPD
14, C2374–C2378, 2014

ERA-Interim to drive the model vertical transport? The total heating rate would include all diabatic processes, although above about 100 hPa both heating rates are very similar.

P9959, L1ff:
Can effects related to chemistry totally be neglected? The authors state that 'neither process is sufficient to explain a short-term change'. It would be good to present results supporting this statement. Further, horizontal mixing with the extratropics (see comment 2) provides a pathway for chemistry related changes in extratropical ozone to affect tropical ozone. Again, these issues have to be critically discussed.

Fig. 4a:
Wouldn't it be better to show also the tropical heating rate as an average between turn-around latitudes, analogously to the mass flux case, and not as an 20S–20N average?

Technical corrections:

P9953, L5: *Age of air changes indicate...*
P9957, L23: *... illustrate ...*
Fig. 4 caption: *... LS all-sky heating rate ...*

References:

Boenisch, H., et al. (2011), On the structural changes in the Brewer-Dobson circulation after 2000, Atmos. Chem. Phys., 11, 3937–3948.

Lin, P. and Fu, Q. (2013), Changes in various branches of the Brewer-Dobson

ACPD
14, C2374–C2378, 2014

Interactive Comment

circulationfrom an ensemble of chemistry climate models, J. Geophys. Res., 118, 73–84.

Abalos, M., et al. (2013), Ozone seasonality above the tropical tropopause: reconciling the Eulerian and Lagrangian perspectives of transport processes, Atmos. Chem. Phys., 13, 10787–10794.

Konopka, P., et al. (2009), Annual cycle of horizontal in-mixing into the lower tropical stratosphere, J. Geophys. Res., 114, D19111.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 9951, 2014.