

Interactive comment on “Unusual stratospheric ozone anomalies observed in 22 years of measurements from Lauder, New Zealand” by G. E. Nedoluha et al.

Anonymous Referee #1

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1 Overall comments

This paper highlights some results from 22 years of stratospheric ozone monitoring by the MOPI microwave radiometer at Lauder New Zealand, and puts them into the large scale context of global ozone and N_2O measured by the MLS microwave radiometer on the AURA satellite. To me, the take home messages from the paper are

- Unusually high ozone in the mid-stratosphere (near 10 hPa) above Lauder in June 2001 was caused by anomalous transport associated with a strong Australian C900

(stratospheric) anti-cyclone, that was unusually stationary above New Zealand throughout June 2001.

- Mid-stratospheric ozone at Lauder (near 10 hPa) shows high correlation with ozone throughout the Southern hemisphere mid-stratosphere (20°S to 60°S, 20 hPa to 3 hPa). It is also anti-correlated to tropical ozone (around 10 hPa, 10°S to 10°N), and to Northern hemispheric ozone (around 20 hPa, 20°N to 50°N). This correlation pattern appears to be caused by QBO modulation of trace gas transports.
- Enhanced ozone in the mid-stratosphere goes hand in hand with enhanced N_2O . Enhanced N_2O is usually associated with faster transport in the Brewer Dobson circulation, which leaves less time for photo-dissociation of N_2O . Less photo-dissociation means less NO_x and less chemical ozone destruction in the mid-stratosphere.
- Over the 2010 to 2013 period, ozone and N_2O mixing ratios have been unusually low around 10 hPa in the tropics, and have been unusually high around 10 hPa in the Southern Hemisphere extra-tropics. The latitude altitude pattern of the 2004 to 2013 trend is very similar for ozone and N_2O , and is very similar to the pattern associated with QBO-related ozone variations at Lauder.
- This anomaly during 2010 to 2013 suggests a slowing of ascent in the tropical mid-stratosphere, and faster transport to the Southern hemisphere mid-stratosphere. The most recent data since mid-2013 indicated that the transport anomaly has ended.

Overall I think this is a good paper and worth publishing in ACP. I do suggest a few minor revisions below.

2 Comments on Text

The text does not always read well, and could benefit from some copy-editing.

page 5243, 1st paragraph. The importance of anthropogenic chlorine, increasing until the late 1990s, decreasing since 2000, should be mentioned here.

page 5243, 1st and 2nd paragraph. Rather than going paper by paper, it might be better to separate declining and increasing ozone trends, before and after 2000. What sticks out from this general picture is the unexpected ozone decline around 10 hPa since about 2002 in the tropics. This different decadal variability is the topic of the present paper!

Pages 5251 to 5253. This discussion is very detailed and hard to follow. Maybe shorten? Or provide more structure / subsections. E.g. start a new subsection "Links between Ozone and N_2O " in line 11 of page 5251.

Start a new subsection "Decadal changes" on line 16 of page 5253?

Page 5254. As mentioned briefly in the introduction, several papers remark on a 2002 to 2013 ozone decline in the tropics near 10 hPa. There is also a recent modelling study by Aschmann et al. (2014) trying to explain decadal variations in tropical ozone. I think some additional discussion is needed in the conclusions section (or before) to put the results from the current paper into this wider context.

3 Comments on Figures

I think it would make sense, to plot satellite data also in at least one of the panels of Figure 3.

Are all panels of Figure 3 necessary? The 10 hPa panel would probably be enough.

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Is Figure 5 necessary? The same information could be incorporated into Figure 3, and more or less appears again in Figure 6. I think Figure 5 could be dropped.

Figure 6: This is quite a good Figure. I don't understand, however, if seasonal means or annual means are plotted. The caption says annual means, but the lines indicate seasonal means. Please correct / clarify.

Figure 9: I think it would be good to also give an indication of the significance of these decadal trends. Looking at Figure 8, it seems to me that the trend is only a small part of the overall variance, and uncertainties in the QBO part of the fit will also result in large uncertainties in the linear trend. Although insignificant trends can indicate a consistent change, they have less meaning for the long-term evolution.

4 Reference

Aschmann, J., Burrows, J. P., Gebhardt, C., Rozanov, A., Hommel, R., Weber, M., and Thompson, A. M.: On the hiatus in the acceleration of tropical upwelling since the beginning of the 21st century, *Atmos. Chem. Phys.*, 14, 12803-12814, doi:10.5194/acp-14-12803-2014, 2014.

Interactive comment on *Atmos. Chem. Phys. Discuss.*, 15, 5241, 2015.