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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Influence of transport and mixing in autumn on stratospheric ozone variability over the Arctic in early winter" *by* D. Blessmann et al.

Anonymous Referee #2

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The manuscript by Blessmann et al. investigates the interannual variability of Arctic stratospheric ozone in autumn and early winter and the processes leading to this variability. It is argued that the ozone variability can be largely explained by the Eliassen-Palm flux as a measure of wave activity during the vortex formation period and in particular the origin of air that is incorporated into the polar vortex. This is a thoroughly performed study and the manuscript is generally well written. I thus recommend publication in ACP after consideration of the following comments.

General comments

The main statements of this study are (a) there is considerable interannual variability

of Arctic ozone in autumn and early winter, (b) vortex ozone in early January is strongly related to the origin of air in September and (c) both the origin of air and consequently the ozone inside the vortex are influenced by the Eliassen Palm flux during the formation phase of the Arctic vortex. While point (b) is discussed in much detail, I feel that a more in-depth discussion of points (a) and (c) would strengthen the manuscript. E.g., in addition to showing the standard deviation only at one level for the four months, it would be interesting to provide these numbers as a function of altitude and for a longer period from summer to winter or even spring. As currently no standard deviations are given for summer and late winter/spring, it is difficult to put these numbers into context. Moreover, how strongly is early winter ozone variability influenced by long-term changes in ozone depleting substances? In other words, is the standard deviation strongly influenced by long-term changes? This is difficult to see from Fig. 1, but principally the information is there.

As it is argued that the wind reversal during the vortex formation period is critical for the propagation of planetary waves and subsequent mixing, it would be helpful to provide also more details for this aspect. E.g., when does the wind reversal takes place, how large is the inter-annual variability in the date of the wind reversal and is this somehow related to the amount of ozone seen in the early winter vortex?

There are a number of figures in the manuscript that do not carry much information in addition to what is given in the text (e.g., Fig. 2, Fig. 4) or in other figures (e.g. information in Figs. 6, 7 and 8 is contained in Fig. 9; information in Fig. 13 is contained in Fig. 14). As some of these figures are redundant the available space can better be used to show addition information for the ozone variability or vortex formation.

Specific comments

p.15084, l.14: "in the lower stratosphere [the EP flux] correlates well with ozone in early winter": Isn't this somewhat in contrast to Fig. 15 that shows a rather modest correlation between ozone and EP flux? If the EP flux in autumn explains less than a

quarter (corr. coef. < 0.5) of the inter-annual variability of early winter ozone (in many cases even much less), are there any ideas for the remaining factors?

p.15085, l.8: "interannual variability increases...and then stays constant": The numbers given in Fig.1 seem to indicate the opposite, namely a continued increase?

p.15086, l.4: if the sensitive period lasts from middle of September to middle of November, why is the Eliassen-Palm flux averaged over the period August to November? How robust are the results to this particular choice? Can you provide more details on the timing of the vortex formation period (see general comments above)?

p.15087, l.7: If data are available for 1991/92 to 2008/09, why is Fig. 1 limited to 1991 - 2005?

p.15088, l.2: "agree well": Can this be quantified? For all levels?

p.15088, l.15: Not the Lyapunov exponent, that is an inherent property of the flow field, is set to 4 days-1, but rather a "critical Lyapunov exponent" or a "threshold value for the Lyapunov exponent".

p.15093, l.5: is this true for mixing as well?

p.15094, l.22: better argue that "both the fraction of vortex air originating from low latitudes and high ozone are connected to high wave activity"

Fig. 15: please provide information in the caption over which period ozone is taken.

Technical corrections

p.15086, l.10: decapitalize Chemistry Transport Model; same for p.15088, l.4.

p.15086, l.23: "higher as" -> "higher than"

Interactive comment on Atmos. Chem. Phys. Discuss., 12, 15083, 2012.