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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Causes of interannual variability of tropospheric ozone over the Southern Ocean" *by* Junhua Liu et al.

Anonymous Referee #1

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The manuscript of Liu et al. discusses the interannual variability of tropospheric ozone over regions where the southern tropospheric ozone maximum is found. This is a well-established feature of tropospheric composition, though such a systematic exploration of its interannual variability in different horizontal and vertical regions, and with a focus on exploring the role of different drivers has not been pursued before. The manuscript is certainly within the scope of ACP, it is generally well written, and the findings will be useful for the understanding of tropospheric ozone variability further. I recommend its publication following some (mostly minor) suggested modifications described below.

GENERAL COMMENT:

If find the second part of the title misleading. The Southern Ocean is mentioned, but this Ocean's northernmost limit is usually taken as 50 or 60S, which is far from where

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Discussion paper

the focus of this study lies. I suggest modifying possibly to “Causes of interannual variability over the southern hemispheric tropospheric ozone maximum”.

SPECIFIC COMMENTS:

Page 2, Line 30: What is special about September, leading to the “even during September” statement. It is not clear at this stage.

Page 2, Line 39: Suggest changing to “especially in the upper troposphere”.

Figure 1: Define “upper tropospheric” in the caption.

Page 4, Line 81: Also, Voulgarakis et al. (2011) demonstrated that between transport processes, it is the STE that is the key driver following El Niño events.

It is also worth mentioning somewhere in the introduction that Hess and Mahowald (2009), who prescribed stratospheric ozone, found that IAV of ozone at 500hPa did not show features similar to the Southern Hemisphere ozone maximum described here (see their Fig. 2 & 3), possibly implying the important role of the stratosphere.

Page 5, Line 121: Please change “section” to “Section”, as there is only one Section 3.

Page 5, Line 129: Gap after http:// not needed.

Page 5, Line 130: Same amount of levels after re-gridding?

Page 6, Line 136: Please check end of sentence and amend.

Page 6, Lines 142-145: Emissions are important, since their role is investigated, so there needs to be an at least brief mention of what they are here. A quick mention of the reference is not enough. Also: Why was specifically 2000 used for the fixed emissions simulation? Any implications of this selection?

Page 6, Line 148: Mention the global total of lightning emissions again. In fact, this is where the more detailed description of what was used for lightning belongs.

Page 6, Line 151-153: Do they vary with time (e.g. are there any trends in CFCs and

N2O, which would affect ozone)?

Page 6, Line 157: They are both artificial, so please specify that you are referring to e90 (i.e. “The e90 tracer is. . .”).

Page 7, Line 168: Why is higher resolution used in this simulation?

Page 9, Line 230: Not clear how the Walker circulation affects the meridional structure of stratospheric ozone contribution, given that the WC occurs in the zonal direction. Maybe the authors mean that the zonal (and not the meridional) variations in the southernmost extent are driven by the WC?

Page 9, Lines 235-237: It is not clear what is suggested here. For ozone in the tropics to be associated with StratO3, I would think that the upper and lower panels of Fig. 2 should have a resemblance in the tropics. That is not something obvious on the figure. Moreover, how can one see an ozone minimum in the three regions mentioned from Figure 2 (upper panel)?

Page 9, Lines 241-242: The Southern Ocean is mentioned, but this Ocean’s northernmost limit is usually taken as 50 or 60S, which is far from where the stratospheric influence is found. I suggest changing to “southern Indian and Pacific Oceans”.

Page 9, Lines 248-251: Please explain why the southern Pacific was not also selected for study.

Page 10, Lines 254-256: It would have been nice to show a simple map with IAVs. Similar to Fig. 1, but for IAV (e.g. standard deviation divided by the mean). It would give an immediate first view of where the “hot-spots” of variability are, both for certain levels and for UTOC.

Figure 3: Why only from 2005 to 2011 and not for the entire period? Also: The labelling of the x-axis could be made more simple/clear.

Page 10, Lines 258-259: This sentence needs to be moved to the caption, to make

clear what is meant by “anomalies”.

Figures 3 & 4: I think “and upper tropospheric ozone column (UTOC, integrated from 500 hPa to the tropopause) anomalies” should be moved earlier in the sentence.

Page 11, Lines 284-285: It would be clearer with IAV maps - as I described above - which areas show larger or smaller IAV.

Page 12, Lines 318-321: Why are the authors mentioning this? Perhaps to suggest that this mechanism is probably responsible for the larger IAV in S. Atl. mentioned earlier, even though IAV in African emissions is small (i.e. there is a remote effect). Please clarify. Also: Perhaps use a clearer term instead of “eastern regions”. I believe this is not a standard term. At the very least you can define its borders in this sentence rather than later. Or perhaps use “South and Southeast Asia”? BTW: The later definition on lines 324-325 does not seem to include Australia.

Page 12, Line 340: Where do those percentages of variability “explained” come from?

Page 13, Line 368: “great” -> “greater”.

Page 13, Line 369: Paragraph too long. Maybe break it here.

Page 14, Line 391: What does a negative response to ENSO mean here? To the ENSO index?

Page 15, Lines 417-418: From the figure it seems that the “eastern region” is the largest contributor, no?

Page 16, Line 443: “lightning activities” -> “lightning activity”.

Page 16, Line 455: “NOX” -> “NOx”.

Page 17, Line 475: Somewhat vague statement. Deep convection transports (mixes up) ozone-poor air from near the surface to the UT.

Page 19, Lines 549-550: Suggest rephrasing to “The stratospheric contribution is still

significant at 430 hPa, but drops to less than half of that at 270 hPa".

Page 20, Line 564: Also in Young et al. (2013) (see their Fig. 3).

Page 20, Lines 569-570: Suggest rephrasing to "to the radiative forcing of climate".

REFERENCES:

Hess, P. and Mahowald, N. (2009), Interannual variability in hindcasts of atmospheric chemistry: the role of meteorology, Atmos. Chem. Phys., 9, 5261-5280, doi:10.5194/acp-9-5261-2009.

Voulgarakis, A., Hadjinicolaou, P., and Pyle, J. A. (2011), Increases in global tropospheric ozone following an El Niño event: examining stratospheric ozone variability as a potential driver, Atmos. Sci. Lett., 12, 228–232, doi:10.1002/asl.318.

Young, P. J., Archibald, A. T., Bowman, K. W., Lamarque, J.-F., Naik, V., Stevenson, D. S., Tilmes, S., Voulgarakis, A., Wild, O., Bergmann, D., Cameron-Smith, P., Cionni, I., Collins, W. J., Dalsøren, S. B., Doherty, R. M., Eyring, V., Faluvegi, G., Horowitz, L. W., Josse, B., Lee, Y. H., MacKenzie, I. A., Nagashima, T., Plummer, D. A., Righi, M., Rumbold, S. T., Skeie, R. B., Shindell, D. T., Strode, S. A., Sudo, K., Szopa, S., and Zeng, G. (2013), Pre-industrial to end 21st century projections of tropospheric ozone from the Atmospheric Chemistry and Climate Model Intercomparison Project (ACCMIP), Atmos. Chem. Phys., 13, 2063-2090, doi:10.5194/acp-13-2063-2013.

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