Atmos. Chem. Phys. Discuss., 10, C9557–C9561, 2010
www.atmos-chem-phys-discuss.net/10/C9557/2010/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "A meridional structure of static stability and ozone vertical gradient around the tropopause in the Southern Hemisphere extratropics" *by* Y. Tomikawa and T. Yamanouchi

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Received and published: 10 November 2010

The authors greatly acknowledge the referee's careful reading and valuable comments. We have revised our manuscript as much as possible following the referee's suggestion. Our final response is described as follows. The referee's comments are presented in Italics.

Response to "Weaknesses that need to be addressed":

Referee comment: Sections 3.1. 3.2 - Need to be more careful when concluding ozone structure "becomes nearly constant" poleward of 65S in Figure 3a. As shown by the arrows, the cross section in this part of the figure is produce by interpolating stations*

near 70S and the South Pole. To what extent the constant structure is due to the lack of data points in between? This data gap issue needs to be mentioned explicitly. Without further evidence, the conclusion on this can only be a weak one.

Author response: Although the absence of the McMurdo data in summer has been already mentioned in the first paragraph of section 3.2, we added another statement about that in the second paragraph of section 3.2.

** In the last paragraph of section 3.2., the authors attribute the large meridional gradient of N2 near 60-70S to the wind shear associated with the polar-night jet. This point is further amplified in the conclusion section (P19185L2-6). To reach this conclusion, citing a relationship as shown in Eq.(1) is not sufficient. Showing the wind field indicating the co-location and structure of the jet is necessary. The inclusion of the wind field is also important for several other statements made in the paper, e.g., L25-26 on page 19184. I suggest the authors to replace the black contours on the cross section figures by relevant wind field.*

Author response: We added latitude-height sections of zonal-mean zonal wind and its vertical shear in austral summer and winter in the manuscript. See the attached figure.

Referee comment: Overall in section 3.3 too many statements are made casually without rigorous physical or mathematical arguments. Some are further included in the conclusion section. Authors are suggested to re-examine the statements there and separate those derived from the data from speculations. Some examples are discussed below.*

** Relationship between N2 gradient and ozone gradient above the tropopause. This is the most problematic part of the manuscript. The authors try to connect the structure of N2 with the vertical gradients of ozone. The statement, "Both of potential temperature and ozone mixing ratio are conserved following air parcel motions without any nonconservative processes", is a trivial one and can be used on any quantity. Although potential temperature is a quasi-conservative tracer of stratosphere, it is well known*

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that the vertical gradient of it is not. The vertical gradient of theta, which is proportional to N2, can change without non-conservative process, compensated by the vorticity change via potential vorticity equation (e.g., see Holton 1992, p98).

In the region of weak vorticity, theta gradient term is the main variable of PV. You may consider using PV - ozone relationship to explain the similarity between the N2 and ozone variability.

Further, the statement of ozone vertical gradient and N2 are "synchronized" is not an accurate one. To be rigorous you would need to show the relationship quantitatively with correlations. If this is intended to be a casual comment and observation, you may want to consider a weaker word, e.g., "similar". This similarity, in contrast to the layer above, is an indication that the variability is largely dynamically driven. The correlation of PV and ozone near the tropopause is known. The issue of how that can be generalized to ozone gradient see comments below.

** Ozone concentration versus ozone gradient. There is a significant issue in the interpretation of Fig. 4, where the regions of low ozone gradient are attributed to the impact of the ozone hole and mixing of ozone depleted air mass in the subvortex region. Here and later the authors implicitly equate low ozone gradient with low ozone concentration. While this is plausible, the step connecting the small vertical gradients to low ozone concentration is missing.*

Author response: As the referee pointed out, this section included much speculation. We decided to delete this section from the manuscript following the referee 2's suggestion.

Response to "Additional suggestions for improving the analysis":

Referee comment: Contour plots with colors can sometimes be deceiving. It may enhance the message significantly if showing a profile plot contrast the N2 gradient and ozone gradient in the Antarctic winter.*

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Author response: Figures 4 and 5 presenting ozone gradient were deleted together with section 3.3.

Response to "Editorial comments and suggestions":

Referee comment:P19177 L6, suggest change to ". . . thermal tropopause can be determined by using only a temperature profile . . ."

Author response: The manuscript was revised following the referee's suggestion.

Referee comment:L8-10, "Over the Antarctic, the temperature of the upper troposphere and lower stratosphere in austral winter and spring is extremely low. Consequently the temperature lapse rate does not change as much as that in . . ."

Author response: The manuscript was revised following the referee's suggestion.

Referee comment:P19178 L19-21, "The latitudinal and vertical structures of the static stability and vertical gradient of ozone mixing ratio in the SH extratropics are captured well in this analysis."

Author response: The manuscript was revised following the referee's suggestion.

Referee comment:L21, " The OBJECTIVE of this . . ."

Author response: The manuscript was revised following the referee's suggestion.

Referee comment:P19180 L12, ". . . their dynamical conditions are similar."

Author response: The manuscript was revised following the referee's suggestion.

Referee comment:P19183 L16, use "Altitude" instead of "height" Similarly, in P19185, L11, and several other places, use "altitude range" instead of "height region".

Author response: The manuscript was revised following the referee's suggestion.

Interactive comment on Atmos. Chem. Phys. Discuss., 10, 19175, 2010.

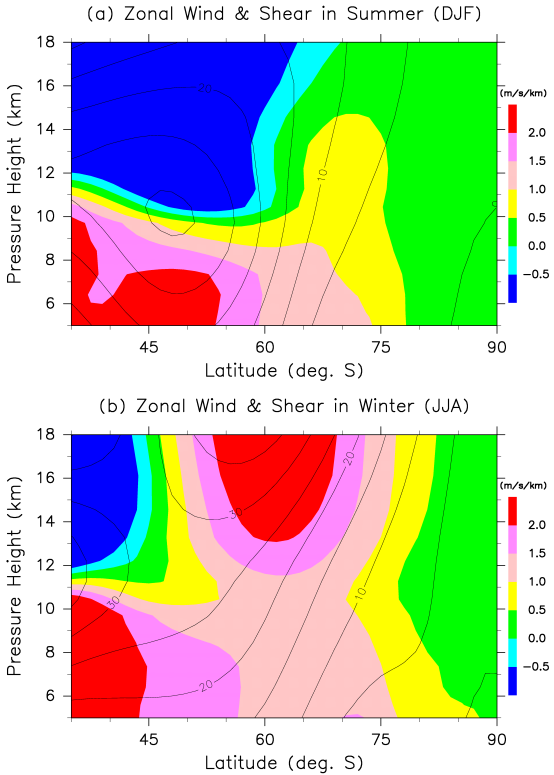

Fig. 1. Latitude-height sections of zonal-mean zonal wind (contours) and its vertical shear (colors) in (a) austral summer (DJF) and (b) winter (JJA) averaged over 1989-2009 using ERA-Interim.

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