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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on “Quantifying transport into the Arctic lowermost stratosphere” *by* A. Werner et al.

Anonymous Referee #3

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The paper by Werner et al. presents an analysis of transport origins of the air mass in the Arctic lowermost stratosphere. Chemical tracer measurements from several aircraft campaigns are used to derive the fractional contribution of tropospheric, stratospheric and polar vortex processed air. The novel result is that the contribution from the polar vortex processed air to this region is significant in winter-spring season. I agree with reviewer 2 that these results are of interest. I have significant concerns, however, of the quality of the analyses and the presentation. The current version of the paper is not rigorously written. The assumptions made in modeling the data have a large uncertainty. There is a lack of clarity in descriptions of data and other information used. The mixture of the two left me wonder if the conclusions are trustworthy. My concerns and suggestions are detailed below.

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Interactive Discussion

Discussion Paper

Main concerns

1. The Lack of rigor in the description of the lowermost stratosphere and related processes. This is mostly reflected in the introduction. Take an example from the last sentence of the first paragraph (L3-8, p1409). A long list of processes, phenomena and locations are mis-matched and lumped together to describe the isentropic transport processes, some are not isentropic/adiabatic (cu-off low, for example). Several sentences in the 2nd paragraph are either ambiguous or wrong. For examples, "STE processes are periodically occurring events, associated with synoptic and mesoscale processes, and do not have a constant influence on the LMS." (L10-12, p1409). And "Due to the vertical stability of the stratosphere, the tropospheric influence cannot penetrate deeper into the stratosphere and is mixed with the downwelling air from the overworld." (L14-16 p1409). Both reviewers 1&2 have already commented on some of the problems here. I will discuss more in the specific comment section. The main point here is that the assumption of isentropic transport is largely unnecessary and hardly used in the analyses presented, why insist on it in the introduction? In fact, the analysis presented is opposite to the assumptions of isentropic transport. If you assume isentropic, the tropospheric boundary conditions should be taken from those isentropes connecting troposphere and lowermost stratosphere in the same levels you report your mass balance analyses, typically from the lower latitudes. On the contrary, you derived your boundary conditions using the lowest part of you profiles, taken at high latitudes and likely below the isentropes of your mass balance analyses. What are the actual isentropes and latitudes of the data that went in the boundary condition calculations?

2. Ambiguities in the data description. Part of the above-mentioned problems is due to the ambiguity in the data description. After reading twice, I am still confused of what are the campaigns, time period, number of flights, latitude covered by the data. What are the dates and fractions of sampling shown in Fig 2., Fig 8 and Fig 9? These made the discussion session difficult to follow.

3. Physical meanings of the negative contributions from the troposphere. Both Figs.

ACPD

9, S533–S536, 2009

Interactive Comment

8 & 9 show negative fractions of tropospheric contribution, especially at high isentropes (380-400K). Little discussion is made to explain the physical meaning of that. Given that the analyses is based on a 3 part mass balance (a triangular box of three sides/boundaries), the results of the first two fractions are not believable if the results of the 3rd one is non-physical. If we look into the regions of negative fractions, they are most likely not troposphere. To what extend these are results of using a tropospheric boundary condition for tropical lower stratosphere, or physically represents equatorward transport to balance the large inflow from the vortex?

Specific comments and suggestions:

1. Critically review the statements you made in the introduction. Check each time you mention STE, if you intend to describe two way exchange or only troposphere to stratosphere transport. STE processes are not "periodically" but "episodically" occurring events and they do have a "constant" influence to the LMS in the sense they always influence but may not be the same amount. Be aware of the convective influence to the LMS. You can justify the effect of that is neglegible in winter. Check into Appenzeller et al., 1996 for seasonality of STE based on mass balance.

2. Improving the data description. Make a table to list the time period covered and the number of flights from each campaign that entered data analyses. What are the sampling rate and corresponding representation of LMS air mass?

3. Examine the assumptions of your entry point values/boundary conditions. How does the values you use from your measurements at delta theta $<$-10K represent the tropical and subtropical upper troposphere, where the isentropic TST would have dictated the airmass? What about the latitudinal gradient of the tracers? What are the known climatology of some of the tracers?

4. Examine the tropical tropopause height for the season of your data analyses. Is the average higher or lower than 380K? That will provide a fact if 380-400 belong to the lowermost stratosphere for the measurement peirod. If not, how many terms should

ACPD

9, S533–S536, 2009

Interactive Comment

you use in the mass balance equation for this region?

5. Provide statistical information of your results. How many data points went in the mean and deviations in Figs 8 & 9? What are the fractions of the low N_2O observations? How well do they represent the vortex season?

6. Check the word "Criterium". It is more common to use "Criterion/Criteria".

Additional Reference: Appenzeller, C., J. R. Holton, and K. H. Rosenlof (1996), Seasonal variation of mass transport across the tropopause, J. Geophys. Res., 101(D10), 15,071-15,078.

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 1407, 2009.

ACPD

9, S533–S536, 2009

Interactive Comment