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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Quantifying transport into the lowermost stratosphere using simultaneous in-situ measurements of SF_6 and CO_2" *by* H. Bönisch et al.

Anonymous Referee #4

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The paper provides a method to calculate the age spectrum in the LMS based on SPURT aircraft observations. In this way, conclusions are drawn about the origin and mean transit time of air from the tropics to the LMS. The paper is well written and the method employed here serves as an important contribution to our understanding of UTLS processes. However, some conclusions in this paper seem to be not consistent with other results. After comments and questions below are addressed, the paper should be considered for publication.

Abstract: Line 13:

The sentence as it stands is not correct. 20% was calculated to be the extreme value

of the tropospheric fraction alpha1. For me, it sounds like the entire LMS composition is characterized by these low values, which is not the finding of the paper. Further, any statement based on this study needs to be considered with caution, because the coverage of observations per season might not be characteristic for the entire LMS (see for example Krebsbach (2006), Conclusions)

Introduction: Line10:

Here, you can mention the study by Olsen (2008) who discussed TST in spring.

Olsen M. A., A. R. Douglass, P. A. Newman, J. C. Gille, B. Nardi, V. A. Yudin, D. E. Kinnison, R. Khosravi (2008), HIRDLS observations and simulation of a lower stratospheric intrusion of tropical air to high latitudes, Geophys. Res. Lett., 35, L21813, doi:10.1029/2008GL035514.

Section 2: Line 15ff:

Please mention, how many or for which flights SF6 is not available. What observations did you use to derive a SF6/N2O relation in real-time?

3.2 Line7: Page 21237, first paragraph and Figure 2, 3, 6, and 7:

The use of the eqlat/theta coordinate system can be problematic, because PV is not conserved everywhere in the UTLS. This is for example the case in the vicinity of the jet stream. I wonder how an altitude versus latitude plot looks like for the quantities shown. Even though the data cover eqlat bins between 40-80 degrees, the location of those data points might be close to the subtropical jet and therefore influence by upper tropical air masses. A plot like that does not have to be shown in the paper, but it would be interesting to know the location of airmasses with regard to the STJ in general.

Further, how many data points are included in each of the data bins in Figure 2,3,4, and 7? How representative is this study? A climatology based on very few flights does not allow generalized statements about transport processes (see for example Krebsbach (2006)).

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Interactive Comment

Line 20:

Can you be more quantitative here? What is the Theta range of the thickness of negative mean age values (and therefore the penetration height of extra-tropical tropospheric air into the LMS)? What is the location and thickness of the ExTL derived in Hoor (2004) and Birner (2006)? How do these values agree?

Page 21238 Line 13ff and Figure 3.

Does Figure 3 include all profiles observed in summer and fall respectively? If so, how does the age of air plot look like for the combined profiles in summer and fall? Figure 2 shows two plots per season. The authors suggest that LMS is flushed by very dry air from the TTL in autumn? Stratospheric H2O is below 10ppm. From the color scale shown in Figure 3, dry stratospheric air can be found in 360 K and around 330-340 K. On the other hand, below 330 K, H2O mixing ratios are between 10-20 ppbm. If the dry air in the stratosphere would be caused by an intrusion of air from the TTL, why doesn't CO show higher tropospheric mixing ratios (as shown in Figure 8, Hoor (2004))? Also Kebsbach (2006) reports strongest influence of stratospheric air during winter and spring and the strongest transport of tropospheric air into the stratosphere in summer. Water vapor mixing ratios are much larger in the summer around 350 K in the stratosphere than in fall (up to 30-40 ppmv), even though the age of air is older than in fall. What is the source of these high mixing ratios? Can the influence of convection be excluded in summer?

Section 4.1

The calculation of the second fraction and therefore the transport of the second pathway is defined reasonably. Considering the Earths surface as the stratospheric entry is certainly OK, if we can exclude the stratospheric intrusions into the region of the tropical TP.

However the definition to calculate the fraction of the transport of the second transport

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pathway can be improved:

It is not clear how the control surface is defined and calculated: The text states: 'The control surface is the tropical and sub-tropical TP'. However, in the following, it is described that 'time series between 0-20 degN are used to represent the temporal behavior of both tracers in the tropical and subtropical region.' Using surface values to calculate the entry function for the first transport pathway between 0-20 degN might be problematic: Depending on season, the STJ can be located between about 10-40 deg N the PJ up to 70 degN. Therefore many exchange processes between Troposphere and Stratosphere at the STJ and PJ are not included in this approximation.

Page 21244, Line 6: How different are the results derived from CO2 and SF6?

General remarks to 21246 and 21247:

A caveat needs to be added that all results described are based on a few observations per season and region.

Page 21250: 'the LMS is flushed with tropspheric air during summer'. How does this statement agrees with the text on page 21238 and Figure 3 'the LMS must be flushed with dry tropospheric air between summer and autumn', so not during summer where water vapor is higher in the LMS?

TST is often connected with the existence of a double tropopause, see Olsen (2008). Randel (2007) have shown that a double tropopause occurs most frequently in winter (50-70%) and much less frequently in summer (10%). How do these findings agree with the statements found in this paper?

Randel, W. J., D. J. Seidel, and L. L. Pan, 2007: Observational characteristics of double tropopauses, J. Geophys. Res., 112, D07309, doi:10.1029/2006JD007904

Figure 4: The transport pathway across the PJ is missing. The PJ, indicated here north of 60 degrees N can occur in much lower latitudes and might contribute to the calculation of the age spectrum.

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Figure 6: The very high tropospheric fraction (100%) in October does not seem to be reasonable. Much higher H2O and CO mixing ratios should be expected as stated above.

Interactive comment on Atmos. Chem. Phys. Discuss., 8, 21229, 2008.

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Interactive Comment