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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Measurements of NO, NO_y, N_2O, and O_3 during SPURT: implications for transport and chemistry in the lowermost stratosphere" *by* M. I. Hegglin et al.

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We thank the reviewer for his or her helpful comments, which helped improving the manuscript.

First comment: We did not include an extra figure, but included the number of data points per altitude bin in Fig. 8 to provide information about the measurement density. We further included a short discussion and the difference between mean and median values in Sect. 4.1 (please see revised manuscript).

p 8656 L10: Yes, equivalent latitude fields have been calculated independently. Text has been improved: *'For the SPURT measurements the PV-equivalent latitude relationships were calculated for 27 individual isentropes from Θ=270 K up to Θ=400 K in steps of 5 K. In this way we obtained a field ϕ_e(PV, Θ) for discrete values of PV and Θ. The equivalent latitude for each measurement point was then calculated by bilinear interpolation onto [PV(t),Θ(t)]. PV(t) and Θ(t) are obtained from a combination of 6-hourly analyses and 3-hourly forecast ECMWF model fields interpolated in space and time onto the flight track [lon(t), lat(t), p(t)].'*

p 8656 L25: We agree with the importance of the work of Plumb and Ko (1993) for our evaluations with the tracer-tracer correlation concept and included a reference in the manuscript. Horizontal diffusion and advection, as explained in the theoretical work by Plumb and Ko (1993), is likely to be the reason for the compact correlations between the long-lived tracers measured during SPURT. This was also shown in a study by Hegglin et al. (2005) who used a simple 2D model including advection and diffusion in order to simulate the tracer distributions in the LMS. Comparisons with the SPURT measurements showed that the model is capable to resolve most of the structures found in the measurements, especially the sloping tracer isopleths which closely follow the shape of the tropopause. However, their results also suggest that, especially in the tropopause region, the parameterization of vertical instead of horizontal diffusion is able to explain the tracer distribution as well or even better. They conclude that mixing processes across isentropic surfaces may therefore also have an important effect on tracer distributions in the LMS. Since Hegglin et al. (2005) parameterized these mixing processes by eddy diffusion, their study may be seen as an extension of the framework of Plumb and Ko (1993) from the stratosphere into the LMS.
The success of $\Delta\Theta$ relative to the tropopause can obviously be explained by the same arguments. However, the use of $\Delta\Theta$ is somehow arbitrary. As shown by Pan et al. (2004) the use of distance from the tropopause in kilometers also results in compact tracer profiles. The latter work is discussed in the final manuscript.

page 8661 L9: This sentence was indeed contradicting the other conclusions and has been removed from the text.

Section 4.3: Tracer-tracer correlations and their seasonality.

Reply: We agree with the reviewer that both the strength of the Brewer-Dobson circulation and the rate of transport of air from the tropics to the extratropics within the tropically controlled transition region (Rosenlof et al., 1997) determine the slope of the correlations measured in the lowermost stratosphere. The third influence would stem from below 380 K by air masses that are quasi-isentropically transported from the tropical troposphere into the LMS (Ray et al., 1999 and references therein). The strong gradients along isentropes found in the SPURT CO measurements and a distinct phase shift in CO_2 present in the background LMS compared to the one in the the tropical troposphere (see Hoor et al., 2004) imply that most of the tropospheric air must have been transported within the tropically controlled transition region. We agree that this information can not be deduced from the O_3–N_2O correlation alone and included these considerations into the revised manuscript.

The technical comments have been incorporated into the revised manuscript:

Figures 2-5: See new figures.

page 8651 L25: Text changed to: *Strahan et al. (1999a, b) presented a climatology of stratospheric NO_y, O_3, and N_2O between potential temperatures of 360 K and 530 K. Their measurements reveal the effects of dynamical features such as transport barriers, and the global mean circulation, on the distributions of these long-lived trace gas species.*

References

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Interactive comment on Atmos. Chem. Phys. Discuss., 5, 8649, 2005.