

Interactive comment on “Measurements of NO, NO_y, N₂O, and O₃ during SPURT: implications for transport and chemistry in the lowermost stratosphere” by M. I. Hegglin et al.

Anonymous Referee #1

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General Comments _____

This paper presents and interprets an extremely valuable dataset, featuring measurements of NO, NO_y, N₂O and O₃ collected on aircraft flights in the lowermost stratosphere in every season during 2002-2003. The authors have made a good job of organising the data, using PV-based equivalent latitude and potential temperature bins, as well as tracer-tracer correlations to present their results. Overall my opinion is that the paper clearly merits publication in ACP, although I have a few comments below that I hope the authors will consider.

My main concern echoes that of one of the other reviewers: namely that there is no means of assessing the density of measurements associated with each SPURT flight in θ - ϕ_e space, and hence the statistical significance of any of the features in Figures 2-5. An extra figure, showing the number of measurements contributing to each bin for each flight might help to resolve the issue, although the real question concerns the number of distinct 'airmasses' that were sampled in each case. At the very least, the paper would be improved by further discussion of sampling issues, including the effect of using the mean rather than the median on the results of Figures 2-5.

Pg 8656 | 10. Has the equivalent latitude field $\phi_e(PV, \theta)$ been calculated independently for the time of each flight? If so, say so here. If it has not been independently calculated for each time period, it should be, as there is presumably considerable seasonal variation in this field. The dataset (ECMWF?) used to calculate $\phi_e(PV, \theta)$ should also be mentioned here.

Pg 8656 | 25. Use of $\Delta\theta$ from the tropopause as a vertical coordinate: Plumb and Ko (1992, JGR-D) discuss the factors controlling the slope of tracer isopleths in the stratospheric surf-zone. They argue that a combination of quasi-horizontal mixing along isentropes and differential vertical advection (upwards in the subtropics, downwards near the polar vortex) cause tracer isopleths to slope relative to the isentropes themselves. If, as seems likely from the compact tracer-tracer correlations found in this study, similar processes are occurring in the LMS, then the slope of tracer isopleths might be explained by similar arguments, and the apparent success of using $\Delta\theta$ as a coordinate might be better explained. Some reference to this body of work should be included.

Pg 8661 | 9. 'Rather being a distinct barrier to mixing, the tropopause thus appears to define the lower border of a region where mixing is generally suppressed.' This statement is not quite consistent with the discussion on pg. 8664 which states that

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there is no significant latitudinal dependency of any of the measured species except in summer (i.e. quasi-horizontal mixing WITHIN the LMS may be strong except in summer).

Section 4.3 Tracer-tracer correlations and their seasonality: I think that only half of the story has been detailed here. The argument that the slope of the O₃:N₂O correlation depends on the ratio of air with a middleworld stratospheric origin to air with a tropical origin seems plausible. But surely this depends on both (a) the strength of the Brewer-Dobson circulation, as discussed, and (b) the rate of transport of air from the tropics to the extratropics, at altitudes above where the measurements are taken. At least below 380K, (b) also has a strong seasonal cycle, approximately out of phase with the Brewer-Dobson annual cycle. The discussion in this section might also benefit from the main results based on the O₃:N₂O correlations being discussed first, and the supplementary / supporting results based on NO_y:N₂O discussed in the final paragraph in connection with Figure 10 (as opposed to the first paragraph, as at present).

Technical Comments —————

A single colour bar should be placed next to each of Figures 2-5, as opposed to each panel, as the current colour bars are much too small.

Pg 8651 | 25. 'Strahan et al...'. I had difficulty making sense of this sentence.

Pg 8661 | 9. 'Rather being...' -> 'Rather than being...'

Pg 8670 | 5. Dynamically, it is the vertical stratification (gradient in theta), not the vertical gradient in PV that acts to suppress vertical mixing.

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

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