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Atmospheric Chemistry and Physics Discussions

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

Anonymous Referee #1

Received and published: 20 February 2009

The paper by Werner et al. presents measurements of various long-lived tracers in northern high latitiudes during the winter 2002/2003. Using these measurements the authors quantify the contributions of different fractions of air contributing to the composition of the lower stratosphere down to the tropopause of high regions. They consider three major source regions: air from the vortex region and extra vortex air above Theta=400K and tropospheric influence from below. Based on their measurements they define boundary mixing ratios and solve a linear equation system assuming linear mixing between the involved air masses.
The paper is fluently written and provides a valuable set of measurements along with a quantitative analysis and a carefull consideration of the uncertainties involved. However, the authors should consider some additional points in their discussion of the

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method and about the representativeness of their concluded fractions.
I recommend the paper for publication after some minor revisions.

Specific comments:
p1412: Discuss the implications using a fixed threshold of 400K as boundary condition, since vertical gradients occur also inside the vortex. You motivate the 400K on p.1410,l.26, which seems to be reasonable. Note that the associated mixing ratios at 400 K also are rather variable over different years particularly over the Arctic. How does this add to the fractions which you obtain? Are the numbers typical or what is the expected range between different years? Note that the extreme profiles are taken in this approach (the low N2O and high N2O cases). How representative are these also in terms for other NH-regions or other winters than 2003?
If you weight the fractions for all your data (not only using the 'extreme' N2O-profiles) on a given Theta-interval, how representative are these compared to the total amount of data?
Concerning particularly H2O, which is mentioned as being the major constraint for the tropospheric fraction: How do different tropospheric source regions impact the results (e.g. tropical and extratropical tropopause)? Do you assume pure isentropic mixing from the tropopause to higher latitudes below Theta=380K? Since H2O is temperature dependent, you would underestimate the tropospheric fraction e.g. at Theta = 360K if a significant amount of tropospheric air from the tropics originating at 380K were included in the air parcel. Is this included in the error?

Some technical comments:
Please add some uncertainties estimates to the numbers in the abstract (maybe based on the mean profiles in Fig8/9.

p1409,l14-16: deeper into the stratosphere, deeper than? Please specify.

ACPD

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p1412,l11/l21: What does the abreviations QR and QL stand for?

1414: l18: Do you mean DeltaTheta < -10K? I guess so (see l.22).
1414: l16. The ozone variability is of course small with respect to stratospheric variability, but how large is it compared to tropopause variability or typical latitudinal gradient along the tropopause?

1415: l10: How does this fit to the findings of Engel et al, 2006, or more recently Hegglin and Shepherd, 2007 who report significant changing influence from overworld air above Theta=380K from autumn to winter? Maybe you could mention some typical ranges for your tracers or a range of variability at 400K.

Fig.4 : Mention green symbols in the caption
Fig.8/9 : Please indicate more clearly the different date of the underlying data (e.g. as plot title), it is difficult to find in the tiny legend.

References:
Hegglin, M.I. and Shepherd, T.:
O3-N2O correlations from the Atmospheric Chemistry Experiment: Revisiting a diagnostic of transport and chemistry in the stratosphere, JGR, VOL. 112, D19301, doi:10.1029/2006JD008281, 2007.

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