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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Turbulent vertical diffusivity in the sub-tropical stratosphere" *by* I. Pisso and B. Legras

Anonymous Referee #4

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Summary:

This paper presents the study of local equivalent diffusion in the subtropical lower stratosphere derived from comparisons between balloon measurements and reconstructed tracer profiles from trajectory ensemble calculations using TRACZILLA using ECMWF winds and REPROBUS O_3 fields. The study ties in with earlier work determining equivalent diffusion for other atmospheric regions, and hence is an interesting contribution to the ongoing research in this field.

The paper is generally well written and I recommend publication after the following comments and technical issues have been addressed.

Specific comments:

p6605 l13 'It should be noted that...' This is the region the authors are most interested in and which deserves some more attention. Some references should be added e.g. Rosenlof et al. [1997] who defined the tropically controlled transition region and describes some of the relevant processes to the mixing in this region, particularly the breaking of synoptic scale waves, and evt. Volk et al. [1995] who quantified enhanced meridional exchange between the tropics and the extratropics using chemical tracer measurements.

p6606 l10: From this sentence and also from the abstract I expect more than one model-measurement comparison, but the fact is that the value for equivalent diffusion of 0.5 m^2s^{-1} is derived from the reconstruction of a single profile obtained during the active stage of the extratropical intrusion only. Say rather '*We will focus on a case study*' rather than '*on cases*' I also suggest rewriting the abstract (e.g. '*The upper bound on the vertical diffusivity in this case study is found to be*') since in its actual form it leads the reader to the wrong conclusion about the generality of the derived equivalent diffusion value.

p6606 l27 ff or p6616 l15 ff: A similar study by Hegglin et al. [2005] determined vertical (cross-isentropic) diffusion in the extratropical tropopause transition using a 2D-advection-diffusion model and comparison with measurements, and found diffusion coefficients between 0.45 and 0.65 m^2s^{-1} in spring which are interestingly of the same order of magnitude as the values presented in this study. Although the absolute altitudes considered in the two studies are different, the altitudes relative to the tropopause and the processes leading to the small-scale turbulence necessary to induce the vertical (and in models unresolved) mixing are comparable. A reference to this work should be included. Hegglin et al. [2005] also include sensitivity studies to changes in the vertical and horizontal diffusion coefficients which showed that vertical diffusion is likely to be more important than horizontal diffusion. Note that I share the concern of Reviewer #3 that the here presented work does not investigate a possible influence of horizontal mixing on the tracer reconstructions. The study by Haynes and Anglade

ACPD
7, S2417–S2421, 2007

EGU

[1997] to which the authors refer to is focusing on the extratropical lower stratosphere at around 50 hPa. Haynes and Anglade [1997] confirmed by their calculations that the characteristic ratio of the horizontal and vertical scales is roughly equal to the inverse of Prandtl's ratio *f/N*, where *f* is the Coriolis parameter and *N* the buoyancy frequency. Since both *N* and *f* change significantly between the tropics and the extratropics, their result that vertical mixing dominates over horizontal mixing might not be valid for the region studied here.

Figure 2/p6607 l14: I don't see evidence for an intrusion from the local minimum in the H_2O profile. The latitudinal gradient in H_2O at these altitudes is very small. During the winter season due to low tropopause temperatures causing very low H_2O mixing ratios in the tropics and due to the enhanced downwelling of older and hence moister air at higher latitudes (through the CH_4 oxidation producing H_2O), one would expect an extratropical intrusion to cause a maximum rather than a minimum in the H_2O profile. Indeed, if you look closely (and to this end you might show the H_2O together with O_3 (down) in the same panel, and the CH_4 with the O_3 (up) in the other panel) it looks like the local maximum in the H_2O profile is correlated with the O_3 peak, both centered at 17 km.

Figure 5: I have a hard time imagining what kind of processes led to the relatively strong ascent of the yellow air masses which presumably are within the LMS where the general motion is downward especially at high latitudes. Since it is known that the winds in the tropics generally lack accuracy I'm also wondering how sensitive the quality of the reconstruction and the derived value for the equivalent diffusion of profile SF2 is to local shifts in the backward trajectory initialization (equivalent to what you've done for profile SF1). Can you comment on this?

Technical comments:

p6605 l5: Please correct '*intrusions of TTL air into the mid-latitude ETLS and, conversely, intrusions of ETLS air, rich in ozone and poor in tropospheric tracers, into the*

ACPD

7, S2417–S2421, 2007

tropical region.'

p6605 l4/7: The use of ETLS and LMS in the paper is not consistent nor is a difference of these two regions as defined by the authors obvious to me. Also the acronym for LMS has to be introduced at its first use. I suggest replacing the 'ETLS' notation by 'LMS' throughout the manuscript, since it is a known notation for the extratropical region between the tropopause and the 380 K isentrope ever since it was introduced by Hoskins [1991]. There is further no need to call it 'extratropical LMS' since there is no 'tropical LMS'.

p6605 l8: I don't really understand this sentence, did you mean 'as shown in climate simulations'?

p6606 l21: Improve '*respectively horizontally and vertically*' maybe by using '*in the horizontal and the vertical, respectively*.'

p6606 l21 ff: What are '*SF*' and '*DMI*'? Please specify at its first use. It would be further interesting to know the average vertical resolution of the measurements in meters.

P6607 l11 ff: This sentence is hard to read. Try something like '*The same panel shows temperature profiles sampled by SF2 during ascent and descent which are nearly identical and reveal a temperature inversion located close to the O_3 peak.*'

P6607 l4: Change to '*This is further suggested by Fig. 4*'

P6615 l20: Change to '*showing that the location of largest gradient agrees very well with the peaks in the Lyapunov exponent*.'

P6616 l23: Change to '*This suggests that D cannot be solely related to the local strain rate*'

P6617 l1: Change to '*and clearly needs to be*'

Figure 1: Please increase font sizes of the lat/lon axis labels.

ACPD

7, S2417–S2421, 2007

Figure caption 2: Change '*with the temperature profile (red) collected during the same flight and the O_3 profile measured by the DMI ozonesonde (black)*.'

Figure caption 3: Change '*Comparaison*' to '*Comparison*'

Figure caption 6: Change '*Derministic*' to '*Deterministic*'

References:

Hegglin, M. I. et al., Determination of eddy diffusivity in the lowermost stratosphere, Geophys. Res. Lett., 32, L13812, doi:10.1029/2005GL022495, 2005.

Hoskins, B., Towards a PV- view of the general circulation, Tellus 43, 27-35, 1991.

Rosenlof, K., A. et al., Hemispheric asymmetries in water vapor and inferences about transport in the lower stratosphere, J. Geophys. Res., 102, 13 213-13 234, 1997.

Volk, M. C. et al., Quantifying transport between the tropical and mid-latitude lower stratosphere, Science, 21, 1 763-1 768, 1996.

Interactive comment on Atmos. Chem. Phys. Discuss., 7, 6603, 2007.