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Interactive comment on "A global climatology of stratosphere-troposphere exchange using the ERA-interim dataset from 1979 to 2011" *by* B. Skerlak et al.

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We thank Chris Homeyer for his detailed comments, which were helpful to improve the presentation of our results. In addition to several smaller changes, a sensitivity study has been added to quantify the influence of the resolution of the trajectory starting grid and of the choice of the PV threshold used to define the dynamical tropopause.

The authors present a comprehensive global analysis of transport and exchange across the 2 pvu boundary (extratropics) and 380 K potential temperature surface (tropics) from ERA-Interim data. There are several new interesting results that re-

quire further attention, such as potential trends in the net transport direction between the troposphere and stratosphere.

I would especially like to complement the authors on the quality of the figures in the paper. In general, I have some concerns and comments on the methods used in the paper that were not mentioned in the discussion. In addition, I think the paper would benefit from a reduced emphasis on the discussion of ozone fluxes given the limitations of such an analysis outlined directly in Section 4 and an increased emphasis on the overall transport characteristics given by the trajectory analysis.

A bit more detail on the method itself, rather than leaving the reader to search in the cited papers, would also be helpful.

We have re-written and significanctly expanded the methods section. The description of the Lagrangian method is now more comprehensive and independent of the previous papers.

Page 11541, lines 14-16 I worry about the sensitivity of your transport calculations to holding the trajectory particle spacing fixed in pressure. I assume this was done for simple mass flux calculations.

Correct.

Since large amounts of TST are typically found in Rossby wavebreaking events that transport air horizontally from the tropical tropopause layer to the extratropical lower stratosphere near the subtropical jet, do you expect to have representative estimates of the transport when you are resolving the dynamics at scales much larger than your primary STT events? For example, the vertical resolution of your 30 hPa grid applied to latitudes poleward of 30 degrees is represented by the included figure. Transport associated with stratospheric intrusions in the middle and upper troposphere is resolved at vertical scales near 500 m, while horizontal transport between the TTL and extratropics is resolved at vertical scales between 1 and 2 km. Since the subtropical jet *and tropopause break are typically near 35N, it seems that your 30 hPa grid would preferentially be resolving the horizontal transport at these levels and consequently at much lower vertical resolution. What is the sensitivity of your transport estimates to the vertical spacing used (i.e., even in altitude versus even in mass)? The distribution of potential temperatures for exchange events shown in Figure 10 would suggest that the sensitivity may be significant, especially when considering the net flux.*

Thank you for bringing this point up. We assume that the main concern is the possibly too coarse vertical resolution and not generally the difference of a vertical spacing constant in height or pressure. With regard to your concern that 30 hPa are too coarse to resolve the structure of tropospheric intrusions from the tropical tropopause layer, we note that in the tropics our trajectory starting grid has a finer vertical resolution (10 hPa instead of 30 hPa in the extratropics). This is indeed important to accurately capture the quasi-horizontal dynamics in this region. Motivated by your question, we have nevertheless performed a sensitivity analysis using a higher resolution of 15 hPa in the extratropics and 5 hPa in the tropics, see Sect. 5.2 in the revised manuscript. The increased resolution has negligible impacts on the geographical patterns as well as the seasonal cycles. We are therefore convinced that the trajectory spacing used in our study is suitable for calculations with ERA-Interim data. Since the different weights of air parcels started in the different regions are taken into account (see below) there occurs no problem at the boundary between the tropics and the extratropics.

Page 11543, line 15 "every trajectory represents: : : 6.52 1011 kg of air" Is this really true for every trajectory? Isn't the particle vertical resolution 10 hPa from 30S to 30N and 30 hPa otherwise?

You are correct. The different weights are of course taken into account when calculating the cross-tropopause fluxes. We have now stated this more clearly in the methods section.

Page 11562, lines 24-27 The asymmetry in reduced fluxes between STT and TST

suggests that the net flux may be nearer zero or has potentially reversed sign for PV = 3.5 pvu.

We have removed this section because now, the sensitivity to different tropopause definitions is discussed in more detail in the new Sect. 5.1. Indeed, the net flux changes sign around the poleward boundary of the extratropics (see Fig. S9).

What is the PV value that most coincides with the lapse-rate tropopause?

In the zonal mean, the 3.5 pvu isosurface corresponds well to the lapse-rate tropopause in ERA-Interim (see Fig. 15 in the revised manuscript). But note that we are not convinced that the lapse-rate tropopause should be used as "the reference".

Many studies of in situ data have shown that the chemical changes (e.g., O3 and CO) are largest in relative altitude to the lapse-rate tropopause (see L. L. Pan et al, JGR, 2004 and others). Because your methods require the use of some dynamical quantity (PV in this case), it may be more meaningful to identify the PV surface that represents the most likely boundary between tropospheric and stratospheric air for ERA-Interim. R. Homeyer K. P. Bowman, JAS, 2013 have shown similar sensitivity in net transport for analyses of Rossby wave breaking events.

The debate of whether chemical changes are largest in relative altitude to the lapse-rate tropopause (e.g., Pan et al., JGR 2004) or the 2 pvu isosurface (e.g., Hoor et al., ACP 2004) is in our opinion not settled yet and outside the scope of this paper. It is also clear that estimates of (net) transport crucially depend on the choice of the control surface. We now discuss the differences between choosing the 2 pvu and the 3.5 isosurface in the new Sect. 5.1.

Figures 8 9 It may make more sense to shift the southern hemisphere annual cycle 6 months so that the seasonality is directly comparable to the northern hemisphere.

We find this a good idea and have modified all the figures accordingly.

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 11537, 2013.