

Interactive comment on “Long-term climatology of air mass transport through the Tropical Tropopause Layer (TTL) during NH winter” by K. Krüger et al.

Anonymous Referee #1

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SUMMARY

Krueger et al. present a climatology of tropical troposphere to stratosphere transport (TST) during NH winter based on trajectory calculations for the period 1962–2005. The trajectories are calculated using ECMWF ERA-40 and operational analysis wind fields in combination with off-line calculated radiative heating rates. As a result of using radiative heating rates rather than vertical wind (ω)-fields, they obtain residence times for TST in the TTL that are longer than those of previous model studies. Interestingly, the spatial structure of the Lagrangian cold point distribution is very similar to that reported in previous work. The results are presented as composites for different ENSO,

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QBO, and solar cycle phases, and for years with volcanic eruptions. The subject of this study is appropriate for publication in ACP, but the authors may want to consider the following points in the revised manuscript.

GENERAL COMMENTS

(1) The calculated radiative diabatic heating combined with the analysed horizontal winds will in general violate mass conservation. A few sentences would be appropriate on how this problem is overcome in the calculations presented here.

(2) The elimination of spurious transport arising from too much dispersion as happens when using the omega-field is certainly a step forward. However, currently available estimates of transit times across the TTL from observations are highly uncertain. Further, the radiative heating rates derived from ERA-40 data and radiative transfer code are not necessarily accurate. Contrary to the claim made in the paper, there are no observations of radiative heating rates available (McFarlane et al. - cited in the paper - derive radiative heating from radiative transfer calculations). The authors miss perhaps the most important aspect of the McFarlane et al. paper in the context of their work: the large discrepancy between cloud radiative heating rates in GCM's and those derived from calculations using ARM data. The ERA-40 model presumably has similar biases. It is therefore not necessarily true that the transit times obtained by this work are close to the 'true' value.

(3) The roles of ENSO and QBO are discussed in detail by Fueglistaler and Haynes [2005], and the discussion provided in this paper does not substantially modify their conclusion. It is thus not exactly correct to describe these results as 'new' (p.14002, 11-6). Also note QBO-induced temperature anomalies occur in phases of easterly/westerly wind *shear*, not east or west phase (or perhaps QBOE/QBOW has this meaning?).

(4) The authors link TTL temperatures variations to variations in upwelling (i.e. Brewer-Dobson circulation). For example, on p.14001 it is stated that the 'coldest and driest

TTL ... during the late 1990's and early 2000s ... consistent with an enhanced stratospheric wave driving observed since the late 1990's'. What has been observed is a drop of water vapour and temperatures around 2000/2001 (not the late 1990's), which Randel et al. (2006) link to an increase in the B-D circulation. The situation in the 1990's seems to be more related to the QBO (Fueglistaler and Haynes, 2005). It would be helpful if the paper were more precise on this point, or show evidence that the B-D circulation was already enhanced in the late 1990's (but why no signal in water vapour?). Also, ERA-40 data has temperature biases that vary over the period of interest here. These biases directly translate to biases in calculated radiative heating, but have little to do with changes in the strength of the B-D circulation. This aspect deserves more discussion. Of interest would be also a comparison of results for pre/after 1979 (satellite era).

SPECIFIC COMMENTS (page/line number)

P13990/L8: Here, and later in the text: Mote et al. [1996] define the tape recorder signal as from 400 K upward. Their reported ascent is typically averaged over a layer in the lower stratosphere. Since your analysis focusses on the layer 360-400K, the tape recorder signal cannot really provide constraints on ascent in that layer.

L10: 'of this part of the circulation': Please clarify which part of the circulation.

P13992/L15: 'even for the upper part of the TTL'; right wording? if anywhere, one would expect the method to deliver good results in the 'upper', not lower part of the TTL? How is 'TTL' defined here?

L25ff: I don't understand. Please clarify statement.

P13993/L11: It's not quite clear who compared what: Did Gettelman et al.[2004] compare the Fu-Liou code to the Morcrette code? A quick check of Gettelman et al. [2004] does not suggest so.

P13994/L19: Sensitivity to ozone is indeed important - but also to clouds. (See point 2

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above). Please discuss this in more detail.

P13995/L13: Do these numbers refer to the total of trajectories, or only the TST ensemble?

P13997/L23: Since a fixed ozone climatology is used, these numbers are almost certainly biased. The phases with lower temperatures are accompanied with lower ozone concentrations (see Randel et al. 2006), which tends to reduce the effect of the lower temperatures on radiative heating rates.

P13998/L5: In a statement about periods of lower/higher temperatures in ERA-40 data one would want to see first how the ERA-40 temperatures compare to, e.g., radiosondes. (see also general comment above.)

P14000/L1-4: This is an interesting statement that has to be shown in more detail. Implications for results of previous studies?

P14002/L10: How significant are the SMAX/SMIN differences? Is there perhaps a fortuitous correlation of the solar cycle with ENSO over the period used here?

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