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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Variability of residence time in the Tropical Tropopause Layer during Northern Hemisphere winter" *by* K. Krüger et al.

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We would like to thank the two anonymous reviewers for their useful comments and suggestions, which help to clarify and improve our paper.

Combined answers to reviewer 1 and 2 general remarks:

As suggested by reviewer 1 we will add a discussion section in the current paper addressing the variability of transit times, possible long-term changes and the effects of latent heating and mixing on transit times. Previous conclusions regarding possible long-term changes are shifted to the discussion now (see detailed comments below). The discussion will consist of the following points:

1) We will discuss the uncertainties of the radiative heating and hence residence time,

which were provided by the first study by Krüger et al., 2008 (K08). As we have already included a detailed case study in K08, we feel that repeating the details of this case study in the current paper is redundant. However, we agree with the reviewer that the results of the case study are of general interest for the readers, and therefore we will summarize the most important findings (based on Fig. 1 and 2 from K08) in our new paper including the effects of the temperature bias and uncertainties in the ozone fields.

2) We will discuss the effects of mixing and latent heat, which are not included in our current study. These effects are addressed by Fueglistaler et al., 2009, who found a residual term of up to 0.1 K/day around the 360K layer in the tropics and by Ploeger et al., 2009, who derived 10% longer residence times for the 370K-400K when including mixing and latent heating.

3) The effects of ECMWF cirrus clouds on our trajectory calculations were investigated by our companion studies by Immler et al., 2007 and Immler et al., 2008, which will be mentioned. Cirrus clouds are resolved in the ECMWF cloud input fields, which we are using.

4) Previous derived transit times from other observational estimates as suggested by the reviewer are added in the discussion section as well. However, the suggested reference by Andrews et al., 1999 is restricted to tropical layers between 390 and 460K and Boering et al 1994 does not provide transit times for the TTL.

5) The uncertainty for the 360-380 K in contrast to the 380-400K layers i.e., the role of latent heating and mixing for the 360-380K is addressed in the new discussion section now.

Detailed comments to reviewer 1: The restriction to the Northern Hemisphere winter months is added now in the introduction.

-P12601. l. 1: changed to > “The climatology maps of tau show averages of trajectory

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ˆportionsˆ inside a 5_×5_ box. Only grid boxes sampled by trajectories are shown."

p. 12602., l. 22: The upper TTL is tau_380-400K, changed. "Faster" is replaced by "shorter" throughout the ms.

p. 12605., l. 29: As mentioned above a discussion is added now in the ms including the main findings of K08 and the observational data base of ERA40.

p. 12606., l. 12 and l. 25: We have tested different pressure levels for the EP flux with tau, but only want to show the maximum correlation. This information is added now.

p. 12606., l 18: "Diabatic upwelling" is changed to "forced diabatic ascent".

p. 12607.l, The maximum correlation is shown (see comment above), the correlation for 380-400K layer is a bit higher than for the 360-380K but not stronger than for 360-400K. This is added in the text now.

p. 12608, l.22: "I suppose the winter 2001-2002 is meant?" Yes thanks, text is changed.

p. 12608, l. 24: The averaged clear sky heating lies around 360K and the LCP at 380 K (e.g. Fueglistaler et al 2009 and fig 1 this study). Thus we are particularly interested in the transit time between the 360-380K layers, when VSLS have reached the stratospheric overworld. We add/motivate this information in the introduction and in the result sections.

p. 12609, l.1: "There are distinct differences between the three considered theta layers leading to the conclusion, that the 380K to 400 K layer is dominated by stratospheric influences, whereas the 360 K to 380 K layer shows more tropospheric influences." Given there is some uncertainty for our 360-380K results (see comments above), we leave this hypothesis out.

p. 12612., Fig. 2, caption: "I suppose that 5 d centred time bins (not Theta bins) are meant¿' Yes thanks, changed.

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Interactive Comment