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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Tracer measurements in the tropical tropopause layer during the AMMA/SCOUT-O3 aircraft campaign" *by* C. D. Homan et al.

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The authors thank Rob MacKenzie for his useful comments and suggestions for improving this manuscript. Replies to the specific comments can be found below.

Referee comment:
P25050, abstract and lines 12ff of the Introduction: If the abstract is to discuss the TTL using potential temperature coordinates, please provide a sentence defining the limits of the TTL for the purposes of the study (i.e., using literature definitions or directly from the SCOUT-AMMA observations).

Response:

The limits of the TTL in this study have been added: “(TTL, here ∼ 350-375 K)”

Referee comment:
P25050, abstract: please distinguish more clearly between the “subtropical tropopause” and the “subtropical barrier”.

Response:
The sentence is rewritten and is now as follows:
“We analyze the data obtained during five local flights to study the dominant transport processes controlling the tropical tropopause layer (TTL, here ∼350-375 K) and lower stratosphere above West-Africa: deep convection up to the level of main convective outflow, overshooting of deep convection, and horizontal inmixing across the subtropical tropopause. Besides, we examine the morphology of the stratospheric subtropical barrier. ”

Referee comment:
P25050, abstract: for clarity, I would suggest “was mostly located at potential temperatures between 350 and 360 K”

Response:
This has been changed.

Referee comment:
P25050, abstract: please be more specific than “not fresh, but of older origin” - assign rough time periods to “fresh” and “older”.

Response:
This has been changed to : “the observed convective signatures were mostly not fresh, but of older origin (several days or more).”

Referee comment:
P25050, abstract: I think the phrase “TTL composition during AMMA” should be qualified to read “gas-phase tracer TTL composition during AMMA” or something similar, to

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avoid the water vapour story.

Response:
This has been changed

Referee comment:
P25051, abstract: 0.2 (20%) is usually thought of as a significant fraction, so this sentence and the sentence prior to it, should be re-written.

Response:
This significant fraction is found at 390 K, i.e. above the tropopause. At this level a significant fraction is in fact expected. To clarify that significant fractions were only found above the TTL the sentence has been modified:

"Using the N_2O observations we estimate the fraction of aged extratropical stratospheric air in the TTL to be 0.0 ± 0.1 up to 370 K during the local flights. Above the TTL this fraction increases to 0.3 ± 0.1 at 390 K."

Referee comment:
P25051, abstract: the final sentence does not deliver what is promised earlier in the abstract (to analyze: horizontal transport across the subtropical barrier) but rather shows why this analysis is difficult. Perhaps there should be some re-wording earlier in the abstract.

Response:
The sentence has been rewritten (see also above the answer to the second comment): "Besides, we examine the morphology of the stratospheric subtropical barrier."

Referee comment:
P25052, line 10: HCL should be HCl

Response:
Corrected.

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Referee comment:
Introduction: I think it is appropriate to cite the three previous papers that discuss TTL tracer structure from Geophysica measurements: MacKenzie et al. (2006), Cairo et al. (2008) and Vaughan et al. (2009).

Response:
The following paragraph has been added to mention Geophysica measurements:

"Several European campaigns were conducted with the Russian M55-Geophysica high-altitude aircraft. In situ tracer measurements were made during the APE-THESEO campaign in February and March 1999 over the western equatorial Indian Ocean (Stefanutti et al., 2004; MacKenzie et al., 2006). Cairo et al. (2008) show with observations above a tropical cyclone made during this campaign that cyclones may induce horizontal stirring of the lower stratosphere, possibly promoting irreversible entrainment of midlatitude stratospheric air into the tropical zone.
The TROCCINOX campaign took place in February 2005 from Aracatuba, Brasil. Konopka et al. (2007) show with a comparison of the in situ measurements of ozone, water vapour, NO, NOy, CH_4 and CO with CLaMS model simulations that vertical mixing, mainly driven by the vertical shear in the tropical flanks of the subtropical jets and, to some extent, in the outflow regions of large-scale convection, offers an explanation for the upward transport of trace species from the main convective outflow at around 350 K up to the tropical tropopause around 380 K.
The SCOUT-O3 campaign over Darwin, Australia in November 2005 was focussed on studying the effect of deep convection on the composition of the TTL (Vaughan et al., 2009). Schiller et al. (2009) found highly localised layers of enhanced water vapour up to 420 K which could be traced to direct injection by overshooting turrets.
In situ measurements of tracers in the TTL have also been conducted using the NASA ER-2 and WB-57F aircraft."

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P25052, line 22: I think “trade-off” is not quite right in this context. It is not that increased subtropical jet dynamics results in decreased tropical convection (is it?) but rather that the TTL composition results from the combined effects of both.

Response:
“Trade-off between” has been changed to “combination of”

Referee comment:
P25052,line 26ff, please modify the discussion here to include Ricaud et al (2009) as well as Ricaud et al (2007).

Response:
Ricaud et al. (2009) has not been added to this paragraph as the purpose of this paragraph of the introduction is just to point out the potential importance of Africa for the global TTL rather than to have an extended discussion about longitudinal and temporal variation in vertical transport, which is the subject of Ricaud et al. (2009). To make clear that the suggestion by Ricaud et al. (2007) that most uplift takes place over Africa is in contrast with other studies (as requested by Referee 2), the paragraph has been changed as follows:

“Ricaud et al. (2007) present satellite data of N_2O, CH_4 and CO and radar data in the tropical tropopause region during NH spring and suggest that rapid uplift over land convective regions, in particular over Africa, may be the dominant process of troposphere-to-stratosphere exchange. However, this view is in contrast to a number of other studies showing that the African region is not an important contributor to troposphere-to-stratosphere transport compared in particular to Southeast Asia and the Western Pacific (Fueglistaler et al., 2004; Berthet et al., 2007; Barret et al., 2008; Park et al. 2007b).”

Referee comment:
P25054, line 9, the CALIPSO satellite is not spelled with a “Y”.

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Response:
Corrected.

Referee comment:
P25055: The impact of convection on the TTL depends not only on mass flux and maximum altitude of outflow, but also on the composition of the air entering the convection. Of particular current interest is the proportion of free tropospheric air entrained into the convection and detrained in the TTL, and what implications that has for the amount of boundary layer air detrained in the TTL (Fridlind et al., 2004). The introduction to this section should be amended to reflect this.

Response:
The following sentence has been added:

"The impact of convection on the TTL may also significantly depend on the fraction and composition of mid-tropospheric air entrained into convection (Fridlind et al., 2004)."

Referee comment:
P25056: I think that the discussion of the importance of overshooting should crossreference other SCOUT-O3 papers on this topic, particularly Ricaud et al., 2009; Khaykin et al., 2009; and Arteta et al., 2009.

Response:
The following sentences have been added/modified:

"During AMMA,in fact, moist layers were observed above the tropopause over Niger up to 19 km and have been attributed to geyser-like injection of ice particles over overshooting turrets (Khaykin et al., 2009). Although impact of overshooting convection on the upper TTL and lower stratosphere is generally accepted and can be numerically simulated (e.g. Arteta et al., 2009; Liu et al., 2010), its importance at global scale is less clear."

Referee comment:

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P25066: “shapen” should be sharpen.

Response:
Corrected.

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