

Interactive comment on “Transport across the tropical tropopause layer and convection” by A.-S. Tissier and B. Legras

Anonymous Referee #2

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Review of “Transport across the tropical tropopause layer and convection”, by A.-S. Tissier and B. Legras

This manuscript analyzes the distribution of convective sources for air that transits the tropical tropopause layer (TTL) using Lagrangian trajectories. Both forward and backward trajectories are analyzed, and the trajectory calculations are supplemented by alternative estimates of mass flux across the top of the TTL. These methodologies are complementary, and combining them yields a more comprehensive analysis that highlights the results that are robust and the results that are less certain. The manuscript addresses a relevant scientific question within the scope of ACP. The conclusions are substantial, and the results are sufficient to support them. The tools, ideas and concepts are not novel, but they are applied appropriately and to good effect. The sci-

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entific methods and assumptions are clearly outlined and detailed enough to permit other researchers to duplicate the study. The sensitivity testing is fairly rigorous (and interesting), although I do agree with Referee #1 that differences relative to previous studies indicate that uncertainties associated with the choice of reanalysis are likely understated here. Overall, I recommend that the paper be accepted pending minor revisions.

General comments:

1. The current title is rather vague and, while accurate in a broad sense, does not properly convey the content of the manuscript. The problem is mostly in the order of the words; for example, something like “Convective sources of trajectories traversing the tropical tropopause layer” or “Convective sources of trajectories entering the tropical stratosphere” would be better. The abstract is concise and complete, but should be edited to improve the clarity. Indeed, while the manuscript text is clear enough to convey its meaning, the phrasing is often awkward and will require editing. A list of editorial suggestions is provided below to aid that process. The figures and references are also generally appropriate, with exceptions noted below.
2. As the CLAUS record has been extended to provide more overlap with the CALIPSO cloud lidar, I wonder if anyone has tried to collocate these observations to assess the actual biases in cloud top pressure derived from CLAUS. This could be done by, e.g., treating the CALIPSO track like a trajectory (which would also incorporate and be used to test interpolation-related uncertainties). Minnis et al. (2008) did a similar analysis for MODIS-derived cloud tops. One could imagine that this could quantitatively (and even qualitatively) impact estimates of the sensitivity of the source distribution (and particularly transit times) to the corrected cloud tops, as the implied correction could depend on the derived cloud top pressure and/or have regional variations. Given that the CLAUS brightness

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temperatures are often used in this way and such a specialized analysis would not stand on its own, I would really like to see someone provide this in one of these studies. Although I feel that it would be appropriate here, I propose this as a suggestion rather than a requirement.

Specific comments:

1. In Fig. 2, lines in the same plot are shown on the same axis, but with that axis representing different aspects of trajectory time (tropospheric source vs stratospheric receptor). Although I don't disagree with the rationale, this choice of presentation is potentially confusing. Given the lack of major month-to-month variability in the proportion of trajectories reaching a cold cloud top, I think that the first result (maximum of 88.7% in April; minimum of 84.7% in July) could simply be reported in the text without graphical representation.
2. It is not paradoxical that transport from convective sources over Tibet is particularly efficient even though the LZRH is high (p.26240, l.11–12) when one considers that the prevailing winds within the anticyclone will tend to isentropically lift these trajectories above the LZRH over the subcontinent.
3. Note that one of the key differences among the studies cited on p.26250, l.16–19 is the choice of reanalysis/analysis data (as well as the representation of convection). In particular, all of the studies identified as agreeing with these results are based on ERA-Interim. Although this is only one region, this reinforces the point that the results may be more sensitive to the choice of reanalysis than indicated by the comparison of ERA-Interim and JRA-55. It's not necessary to provide more sensitivity studies here, but section 4.3 should also include relevant contextual information from previously published results.

Technical suggestions:

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p.26232

l. 4: "The tropical domain being sub-divided into 11 regions" → "After dividing the tropical domain into 11 regions"

l. 9: "all along the year" → "throughout the year"

l.11: This sentence is too long. Suggest something like "During boreal summer, the Asian monsoon region is the largest contributor, with similar contributions from the maritime and continental parts of the region; however, the vertical distributions and transit times associated with these two subregions is very different. Convective sources are generally higher over the continental part of the Asian monsoon region, with shorter transit times."

l.15: This statement about the plateau is poorly worded and could easily be misinterpreted (particularly the use of "highest impact"). Suggest something like "The Tibetan Plateau is a minor overall contributor, but transport from convective sources in this region is very efficient due to its central locations beneath . . ."

l.17: Suggest "The core results are robust to uncertainties in data and methods, but details of the vertical source distributions and transit times are somewhat sensitive to the representations of . . ."

l.25: "At the same time" is vague; suggest replacing with "In the absence of convection"

l.26: This sentence is rather long; suggest starting a new sentence with "The TTL region encompasses . . ."

p.26233

l.4-5: ", its spatial and temporal variability. . ." → "and their spatial and temporal variability. . ."

l.10-11: This sentence is also quite long; suggest starting a new sentence after "380 K surface" and replacing "upon the combined effect of. . ." with something like "We examine the relative roles of. . ."

l.29: typo: "t" → "to"

p.26234

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l.6-7: typo: “Holton et al (1995)” should be a parenthetical rather than text citation?

l.19: suggest omitting “very” here

l.24: typo: “An other” → “Another”

p.26235

l.16: typo: “calculation” → “calculations”

p.26236

l.15: “ending their flight in this way” → “eliminated for this reason”?

l.16: “affects only marginally” → “only marginally affects”

l.24: “Sea of China” → “South China Sea”; “the Tibet” → “the Tibetan Plateau”

p.26237

l.4: “on the average” → “on average”

l.14: “domination” → “dominance”

l.18: “dominates” → “is the leading source” (as it is not a majority)

l.19: “caps” → “peaks”

l.22: typo: “is” → “a”

l.23: suggest changing the format: “, see Fig. 2b,” → “(Fig. 2b)” — here and elsewhere in the manuscript

p.26238

l.2: “quasi-identical over the whole year” → “almost identical throughout the year”

l.3: “, that is three times its backward contribution but” → “(three times its backward contribution), but”

l.9: “defined in” → “derived by”?

l.11: suggest adding “in the backward case” at the end of the parenthetical for clarity

l.15: “transport chaos” → “the chaotic aspects of transport”

l.29: “efficiency” → “efficiencies”

l.30: “fades in” → “ramps up”?

p.26239

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l.11: “19,5% from” → “19.5% are from”

l.20: overlong sentence; suggest starting a new sentence after “355 K” to state that the mean cloud top of source clouds is above the LZRH

l.23: typo: “exhibit all” → “all exhibit”

l.29: typo: “distribution” → “distributions”

p.26240

l.5: add “The” before “Africa modal peak”

l.6: specify that the common winter is 355 K for clarity.

l.26-27: this last sentence is vague, and should be rephrased for clarity: “Transit times from Af show very little change . . .”

p.26241

l.4: “large scale intense circulation” → “intense large scale circulations”

l.20: “visible” → “evident”?

l.23: I’m not quite sure what “aisle” is meant to refer to here — the peak? the overlap between two distributions?

p.26242

l.3: “87%” → “88.7%”? — this would match the number reported in section 3.1

l.6: missing “range” after “within the”

l.13: “Accordingly to” → “In accordance with”?

l.16: “distribution which” → “distribution, which”

l.29: typo: “distribution” → “distributions”

p.26243

l.5: “quite opposite, qualitatively” → “qualitatively opposite”

l.10: “may be quite erroneous” → “may contain large errors”

p.26245

l.1: typo: “mode” → “more”

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l.5-6: “where the bars stands for the zonal average” → “, where the overbar indicates a zonal average”

l.6: “This” → “The”

l.12-13: I think that the references should be pointing to Eqs. (1) and (4), rather than to Figs. 1 and 4.

l.16: typo: “average” → “averaged”

l.18: the reference is again to Fig. 4 rather than Eq. 4

l.21: “the ERA-Interim” → “ERA-Interim”

p.26246

l.1: “noticeable” → “notable”

l.2-3: “because this domain of the surface 380K is heated everywhere all along the year in monthly average” → “because monthly mean diabatic heating rates on the 380 K surface within this domain are positive throughout the year”

l.4: “noticeable” → “notable”

l.4-5: suggest rephrasing for clarity: “little change in the upward flux as the domain is expanded, because most of the upward motion occurs within the 20°S–20°N band.”

l.7-8: “mean to constrain” → “means of ensuring”

l.9: typo: “transfers” → “transfer”

l.9: long sentence; suggest starting a new sentence “radiative transfer. Actually, the mean. . .”

l.15: “the sequel” → “the subsequent analysis”?

l.20: suggest rephrasing for clarity: “only on the order of 1–2%. This shift is negligible and cannot explain. . .”

l.29: typo: “know” → “now”

p.26247

l.2-5: long sentence; suggest starting a new sentence “after the launch. Here, the interval Δt is always a multiple of 24 h to ensure that the averages are taken over an integer number of daily cycles.”

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l.22: “the grid point within the domain” → “all grid cells within the tropical domain”

l.23-25: suggest rephrasing for clarity: “Then the contributions of parcels originating from each source region are quantified. The total contribution of each source region is calculated by summing the contributions over all tropical grid cells.”

p.26248

l.4: “where labeled with” → “are labeled according to”

l.5-6: suggest starting a new sentence after $M_{\text{back}}^{\uparrow}$ and rephrasing for clarity: “The difference between these two estimates has a mean of. . .”

l.9-10: I’m not sure I quite follow this statement — is the source curve in Fig. 2a supposed to be the sum of the individual regions (which are arranged relative to intersection with convection) or the total number of trajectories coming from convection (which are arranged relative to release at 380 K)? Is the shift a lead or a lag? This sentence should be clarified.

l.14-16: as this sentence is a continuation of the previous statement, it would be appropriate to include it in the previous paragraph rather than on its own.

p.26249 l.12: rephrase for clarity: “representation of the cloud tops and the reanalysis used to drive the trajectories.”

l.14: “while” → “but”

l.20-22: long sentence; suggest starting a new sentence after “15 days”: “Transit times are shorter from convection over continental Asia during boreal summer (. . .)”

l.23: suggest starting a new sentence after “longer” for clarity: “The discrepancy between forward and backward transit times is most pronounced for transport from convection over Tibet.”

l.24: “motivation” → “motivations”

l.26: suggest rephrasing for clarity: “mostly (80%) located slightly above the LZRH, but not by much.”

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p.26250

l.1: "is providing" → "provides"

l.2: "to determine" → "in determining"

l.3: missing "be" before "further demonstrated"

l.4: typo: "rise" → "raise"

l.17: I believe that this citation should be to Wright et al. (2011) rather than Wright and Fueglistaler (2013)

l.19: typo: "out" → "our"

l.26-27: typo: "convective" → "convection" (or "convective transport")

p.26251

l.11: "creates" → "highlights"?

l.11-13: suggest starting a new sentence after "needs to be solved": "Transit times are an important factor in understanding and modelling the behavior . . ."

l.13: "short live" → "short-lived"

l.15: for clarity, suggest "provider" → "source of stratospheric air"

l.19: suggest adding "over land" at the end of this sentence for clarity

p.26257

caption:

"in K" → "potential temperatures in units of K"

"The regions with low contribution" → "Regions with low contributions"

p.26258

caption:

"day" → "units of days"?

"The regions with low contribution" → "Regions with low contributions"

p.26259

caption:

"in italic" → "italicized"?

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p.26261

figure:

recommend reordering the legend so that it matches the order in the caption, left to right (also Figs. 2–8)

p.26262

caption:

for clarity, recommend using "380 K isentropic surface" rather than "tropopause" here

p.26263

figure:

I'm not sure what the y-axis labels mean; perhaps change to 'Count [month⁻¹]' or similar (also Figs. 5, 7 and 8)

p.26264

caption:

if the distributions are normalized, then they should not have a unit — or is your meaning of 'normalized' different?

p.26267

figure:

recommend reordering the panels so that season is top/bottom and category is left/right — although this makes it more difficult to evaluate the relative locations of the modal peaks, it makes it easier to compare the distributions (i.e., redistribution among regions) and would be consistent with the previous figures (thereby limiting confusion).

p.26268

figure:

it may be worth repeating the upper panels of Fig. 7 and showing this as a four-panel figure to facilitate comparison.

p.26270

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caption:

“that it” → “which is”; “which originates” → “that originates”

p.26271

caption:

suggest rephrasing for clarity: “Mean annual cycles of monthly upward mass fluxes through the 380 K isentropic surface within the 40°S–40°N band attributed to each source region. Fluxes are based on backward trajectories during 2005–2008.”

suggest rephrasing for clarity: “Time is defined relative to back trajectory launch at 380 K, rather than the convective source.”

References

Minnis, P., C. R. Yost, S. Sun-Mack, and Y. Chen (2008), Estimating the top altitude of optically thick ice clouds from thermal infrared satellite observations using CALIPSO data, *Geophys. Res. Lett.*, 35, L12801, doi:10.1029/2008GL033947.

Wright, J. S., R. Fu, S. Fueglistaler, Y. S. Liu, and Y. Zhang (2011), The influence of summertime convection over Southeast Asia on water vapor in the tropical stratosphere, *J. Geophys. Res.*, 116, D12302, doi:10.1029/2010JD015416.

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