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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Impact of the Asian monsoon on the extratropical lower stratosphere: trace gas observations during TACTS over Europe 2012" *by* S. Mueller et al.

Anonymous Referee #1

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General Comments

This paper uses aircraft trace gas measurements in the extratropical UT/LS from late summer 2012 to analyze atmospheric composition change. The cause of those changes is shown to be the Asian monsoon. Although this is a lengthy review, it is 98% about language and writing, not science. I think the science presented here is very good, and find only one science issue that needs to be addressed. Scientifically, I suggest revisions to Section 4 and accompanying figures. This paper would benefit substantially from language improvements and I have suggested many below; I hope they help. This paper is appropriate for ACP and will be suitable for publication after

minor scientific revision and somewhat more substantial language improvement.

The minor science issue involves Section 4.2. I don't like the approach taken in using the N2O-O3 correlation to identify changing tropospheric influence. I think there is a better approach possible, but I am also not sure that the results of 4.2 present additional information compared to 4.1. It may make sense to combine and shorten 4.1 and 4.2 by eliminating redundant analysis. Please see the comments regarding pages 83-84.

Specific Language and Science issues For all comments below I refer to the last 2 digits of the ACPD page number (e.g., P85), and 'l' refers to the line numbers.

P67, first sentence of Intro. It is contradictory to say that the impacts are not well known but then provide 9 references on the topic – clearly something is known. I would delete this sentence and incorporate these references into the text as appropriate. You can use the 2nd sentence to start the section but delete 'In general'.

P68, l2. It sounds like the tropopause is exerting a force that suppresses exchange, which is not exactly correct.

P68, l3. 'In the tropics the UTLS'. . .I believe the tropical portion of the UTLS is referred to as the TTL, not the UTLS. Rewrite accordingly.

P68, l5. Not 'Contrary', you mean 'In contrast, . . .'

P68, l10. I would say the LMS is vertically defined by the tropopause. . .

P68, l20-23. This is a 1-sentence paragraph. It belongs at the end of the previous paragraph.

P69, l1. 'gains' should be 'has gained'

P69, l3. Delete 'Generally'

P69, l15. The sentence 'The pathway and strength. . .' sounds like it might be the start of a new paragraph. Also, regarding that the TST is 'neither adequately understood

ACPD
15, C10943–C10951, 2015

nor quantified'. . .weren't there 9 references on this topic given in the first sentence of the Intro? Something must be known.

P69, l 24-29. This is a 2-sentence paragraph. It makes more sense to combine it with the previous paragraph, and perhaps break that previous paragraph in two.

P71, l9-13. This paragraph could be much clearer. There are 13 flights but you look at only 7 of them, so that's all you need to mention. Suggested rewrite: '. . .provide the basis for this study. A large dataset of high spatial and temperature resolution mainly in-situ trace gas data was collected in the Ex-UTLS. This paper focuses on seven research flights extending from 15 to 70N and 25W to 15E, each lasting 8-10 hours. There are 65h of trace gas measurements in the Ex-UTLS, with 40 of those hours in the stratosphere.' Also, why 'mainly'? As far as I can tell, ALL the data used here are from the in situ instrument. If this is the case, delete 'mainly' (here and anywhere else it is used).

P72, l3. '10s or 0.1 Hz, respectively'? 10s is 0.1 Hz and there is nothing to be 'with respect to'. Change to 'a time resolution of 10s (0.1 Hz), corresponding to. . .'.

P72, l7. Change to 'a 3 channel. . .spectrometer that measures CO, CO2, and N2O. . .'.

P72, l15. Delete 'Therefore' and begin sentence 'The in-flight calibrations identify and correct. . .'

P72, l17 & l19. Delete 'finally' and delete 'respectively'

P74, l2. Delete 'Hereby' and change to 'Diabatic heating rates are used to calculate vertical velocities. . .'

P74, l11. Change to 'On the highest flight levels of 150 and 130 hPa, air masses with. . .'

P74, l23. Delete 'performed'.

P75, l2. Change 'respectively, partly chemically processed. . .' to 'partially processed'

ACPD
15, C10943–C10951, 2015

P75, l4-7. What is meant by 'the stratospheric equilibrium of CO'? CO 'degradation' is 'CO loss' or 'CO oxidation'. I believe what you're saying is that CO between 20-30 ppb indicates that the air is older than tropospheric air but younger than air above the LMS. Could you instead say something about how old you think air is that has 30 ppb CO, and how old air is that has only 12 ppb?

Regarding Fig 1a&1b, I suggest leaving off the colored overlays that indicate different mixing lines. This is confusing and it's hard to see colored lines on top of a color contour map.

P75, l20-22. Please rewrite and clarify. Is it the analysis that is 'first time', or is it the observation of mixing lines above 380K that it new?

P75, l 28. Change this sentence to 'Linearly correlated data points with enhanced CO. . .'

P76, l3. Change this to 'During TACTS Flight 2, 5 mixing lines (ML) at the potential temperatures. . .'

P76, l5-6. If you removed the colored mixing lines from Figs. 1a and 1b (and I hope you will), this sentence will have to change.

P76, l8. Delete 'identified' ('The five identified mixing lines...')

Is Table 1 necessary? What use are they to the reader?

P77, l2-11. This is a muddled and confusing introduction to this section. It needs a rewrite that is organized along these lines: 1. "This analysis seeks to determine. . .." 2. "The difficulties are. . ." 3. "We use the method of blah blah to determine the tropospheric end members. . ." 4. "We apply this method to all ML."

After rewriting, make this a separate paragraph and start the new paragraph with line 11 ('Figure 3 displays the tropospheric end member . . ."). No 'exemplarily'.

P78, l9-11. Suggested rewrite: "A tropospheric CO end member lower than typical

ACPD
15, C10943–C10951, 2015

tropopause values indicates that. . .”

P78, l12. By ‘chemically unprocessed, not CO degraded’ do you mean ‘not photochemically aged’? If so, this is a more precise way to say this.

P78, l13 & l25. Delete ‘determined’ and ‘investigated’.

P79, l5-8. This begins awkwardly. Try: “We investigate the origin of ML 1, 2, 4, and 5, which were observed in the trough away from sharp isentropic PV gradients at the tropopause, by analyzing 50-day back trajectories calculated with the CLaMS model. Variations of potential. . .”

P79, l17. Suggested rewrite: ‘These trajectories appear preferably for air masses with large PV (>8 PVU) in regions with the observed mixing lines.’

P79, l21. Delete ‘significant’

P80, l1. Change ‘suggest’ to ‘suggests’

P80, l6. Change to ‘The calculation of 50-day back trajectories. . .’

P80, l10, change to ‘Clams calculates the vertical motion. . .’

P80, l16, Change sentence to begin “Trace gas measurement of . . .”

P81, l2-6. Delete this entire last sentence (beginning, “Subsequently,. . .”). You don’t need to explain what’s ahead.

P81,l9-15. This introductory paragraph could be much clearer and it calls Figures 9 and 10 in the wrong order. Here is a suggestion: “We investigate the effect of the Asian monsoon on the trace gas composition of the Ex-UTLS by examining the changes in N2O, CO, and O3 from the early (28 Aug-5 Sep) to the later TACTS flights (23 Sep-26 Sep). The distribution for each period is calculated as the average of the flight data binned by equivalent latitude and potential temperature. Figure 9 shows the data coverage for each period. Figure 10 shows the mean distributions for N2O, CO, and

ACPD
15, C10943–C10951, 2015

O3 in the early and later periods as well as their differences."

P81, l16-17. Try this: "Figure 10 shows no significant changes for N2O and O3 in the ExTL."

P81, l19. Delete 'during TACTS'. In fact, throughout this paper, phrases such as 'during the flight campaign' and 'during TACTS' are often unnecessary and should be deleted. It is implicit that the analyses are about the TACTs data.

P81, l20. Change to 'Both indicate. . .'

P81, l22-24. These 2 sentences could be succinctly combined: "This finding is true for the relatively short-lived species CO, which decreases in the ExTL but increases slightly above it."

P82, l3-7. The changes aren't just above 380K but are also down to 350K.

P82, l8-10. I'm struggling with the words here. Is this the intent: "If rapid transport of tropospheric air into the stratosphere were responsible for increased tropospheric signatures above the ExTL, CO would also have increased in the ExTL ."

P82, l12. Instead of 'At this point. . .', try "It is likely that strengthening of the jet stream in September weakens transport of tropospheric air masses into the ExTL. . ."

P82, l16. Change to "Independent of this transport. . ."

P82, l21. Delete 'Hereby'

P82, l20-26. Try: "The top panels of Figure 11 show the percentage of 50-day back trajectories originating in the Asian monsoon region (criteria. . ..) using the same coordinate system as Fig. 10. The mean residence times of the Asian monsoon trajectories between t=0 and 50 days are shown in the bottom panels." Also, move these two sentences to the paragraph below it.

P82, l27. I agree that there are quite a few trajectories in the ExTL in early TACTS that

ACPD
15, C10943–C10951, 2015

originated in the monsoon, but they are not the 'predominant' origins.

P83, l1-10. I agree in general with what you say, but I don't get the significance of the residence times – can it be better explained why these matter? If they aren't essential to your argument they could be eliminated. 'Fewer' not 'less' trajectories. Are you certain that the jet is actually creating a transport barrier, or is it that the monsoon weakens so there isn't the anticyclone 'forcing' the transport of tropospheric air? I think that the difference panel in the top row of Fig. 11 is the most convincing part of your argument, particularly because it shows differences in the same location as the N2O and CO increases in Fig. 10 while the differences along the ExTL are near zero. The spatial agreement with Fig. 10 might be emphasized there.

P83, l20-22. This reasoning isn't quite right. The tropical vs. older air N2O-O3 correlation you describe is true for the stratosphere, not the troposphere. In the troposphere they are nearly uncorrelated because N2O is very high everywhere while O3 can vary. If the monsoon air is highly polluted there will be (relatively) high O3 and high N2O, but in clean air there will be low O3, high N2O. 'Relatively large O3 on a given N2O level' will be an indication of pollution, not tropical origin.

P84, l1-25. I don't think this is a good analysis. By separating the data into the low (red) and high (blue) O3 mixing ratios you are making assumptions about the origin of these air masses. If you want to identify a change in air mass between early and later TACTS, a more unbiased analysis would be to plot histograms for N2O (O3) for the early flights, then overlay the histograms for the later flights – similar to the plots in Fig. 13. (The histograms could be filtered by theta above the ExTL perhaps.) This should reveal the composition change during September. (The species shown in Fig. 13 should then be analyzed in the same way.) It might be useful to calculate histograms for more than one theta or height above the tropopause to make points about transport contributions at different levels.

P84. I'm not sure that this section (4.2) is actually providing any new information com-

ACPD
15, C10943–C10951, 2015

pared to Section 4.1 It seems like it's just another approach to getting the same information. If there is a result in 4.2 that was not shown in 4.1, please make it clear what that is. If there is no new result here, consider combining 4.1 and 4.2 and eliminating redundant analyses. Also, consider modifying the section title to alert the reader to the goal of the analysis. That is, instead of 'Trace Gas Distributions and Variability of. . .', Section 4 could be called 'Diagnosis of monsoon transport in the extratropical lower stratosphere'.

Section 5 (P85 & P86). The summary should be prose, not numbered statements. I suggest that you integrate the content of the numbered statements into the discussion paragraphs on P86. By this I mean, begin Section 5 with p86, l4 ("This study shows that the transport from the Asian monsoon region. . .". Within this paragraph, say how the results of the analysis support the discussion. Do the same for the 3 paragraph on P86.

Regarding P86, l13, I don't think the data demonstrate this pathway, they only suggest it.

P87, l2. Ratios are not transported, air is. Please rewrite.

P87, l14-17. Suggest combining and shortening these 2 sentences: "We conclude that the observed increase in tropospheric influence in the ExTL above 370 K originates in a region with a high tropopause. The calculation of 50-day. . ."

P87, l18-22. These 2 sentences say almost the same thing. Try combining: "In agreement with the tracer observations, the CLaMS trajectories show an increasing contribution of air originating in the Asian summer monsoon to the extratropical lower stratosphere during September."

Notes on Figures

Fig. 1 caption. 'equally to a)'??

Figure 3. White dots with black error bars?? Can't see this.

ACPD

15, C10943–C10951, 2015

Fig. 5 caption. ‘trajecetories’

Fig. 7 caption. Time is shown in month/day, not UTC.

Fig. 9 & 10 captions. Delete everything after ‘(WMO, 1957)’. That’s a really ancient reference!

Fig. 11 caption. The word ‘day’ is missing from ’50 backward. . .’

Miscellaneous

Replace ‘backward trajectory’ with ‘back trajectory’ throughout.

In general, 1) delete words like ‘Hereby’ or ‘Thus’ or ‘therefore’ from the beginning of sentences, 2) change ‘the presented study’ to ‘this study’, 3) change ’50 day trajectories’ to ‘50-day trajectories’, 4) don’t use ‘respectively’. It’s either wrong or unnecessary in most cases, and 5) try to write in the ‘active voice’. That is, instead of ‘The effect of blah blah is investigated’ try ‘We investigate the effect of blah blah.’

P67, l8. ‘trajetory’ (trajectory)

Numerous places (please search), ‘seperate’ should be separate.

P74, l9. ‘Europa’ (Europe)

P82, l17. ‘Fligth’ (flight)

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ACPD

15, C10943–C10951, 2015