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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 #2

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This manuscript reports a data analysis work using airborne in situ measurements from the HALO research aircraft during a 2012 field campaign TACTS. The main conclusion is that strong tropospheric influence is found in the midlatitude lower stratosphere near 380K using tracer–correlations. Back trajectory analysis shows that the Asian monsoon uplifting is the main contributing process. The manuscript has some significant shortcomings and needs to be re-evaluated after major revisions.

General Comments (along the three ACP review criteria)

1. Scientific significance

The scientific significance of the manuscript is weak. The work presented has not pro-

vided new scientific insight. To improve upon this, I suggest the authors consider making the following points: What is the scientific significance if air mass in the observed mid-latitude location near 380 K is influenced by the Asian monsoon? What difference would it make if the tropospheric influenced air came through the monsoon region instead of the "regular" tropics? What's the chemical impact of this transport pathway, qualitatively and quantitatively? In which way do you expect these observations to help improve models?

2. Scientific quality

The scientific quality of the manuscript needs improvement, mostly because the discussion shows significant conceptual ambiguities (see Specific Comment 1). There is also a lack of quantitative results (see Specific Comments 2&3). The discussion is not focused enough on the objectives.

3. Presentation quality

The presentation quality has some shortcomings. The figures look as if they are at the exploratory stage of the data analysis. They are not refined enough to be concise and quantitative. There are too many repetitions (Figs 5&6, Figs 2&8, Fig 14). There are also a number of language and grammar issues.

Specific Comments:

1. Conceptual ambiguities reflected in the choice of terms

It is difficult to get a clear physical picture of the result. The use of the term Ex-UTLS contributes significantly to this problem, especially the frequent use of "Ex-UTLS above 380 K". If the focus of the paper is on the transport of tropospheric air into lower stratosphere by the Asian monsoon, refereeing the region of destination as the Ex-UTLS above 380 K defeats the purpose in multiple ways: 1) Extratropical UT is almost never above 380 K, arguably with exception of the Asian summer monsoon; 2) the UT is really not of interest here, and 3) having tropospheric influence in the UT is not a meaningful statement. Because of these reasons, the statement of "Asian monsoon has impacted Ex-UTLS" is not meaningful. Furthermore, Lowermost Stratosphere (LMS) is a main component of the Ex-UTLS. It is a logical self-contradiction to conclude that there is an intensification of tropospheric influence in the Ex-UTLS and a weakening influence in the LMS the same time period (abstract). Similarly ExTL is also a part of Ex-UTLS. To discuss them in parallel creates a lot of confusion, especially when the specific divisions are not marked in the figures.

2. Purpose of the mixing-line discussion

The discussion of the mixing lines is a significant part of the paper but did not produce quantitative result. The analysis and discussion are somewhat narrowly conceived and the focus is on the "straight mixing lines" and whether one of the two end points represents "pure troposphere". The early "classical" mixing line and tracer correlation papers, Waugh et al., 1997 and Plumb 2000, for example, have concise descriptions on the effects of mixing on tracer relationship. The concept of sustained mixing discussed there is very relevant to this work. Using the Waugh/Plumb framework, the slope and the shape of the mixing line would be able to help quantify the tropospheric influence through direct mixing (a single mixing with one end point consisting of the tropospheric background air) or multiple, sustained mixing. Since you are restricting the analysis to the stratospheric measurements, the Waugh and Plumb framework may be as relevant as, if not more than, the "L -shape" discussion.

Also note that many tracers go through sharp changes at the exra-tropical tropopause. The tracer's "tropopause value" is somewhat an ill-defined quantity.

3. Seasonal evolution discussion

Overall the seasonal evolution analysis (Figs 10-15) does not bring out clear quantitative information and is also weak in physical interpretation. If the separation of the ExTL and the layer above is of strong interest, I suggest the authors to examine the (1D) distribution change in tracers with season in the two layers (histograms). Overall

the 2D distribution figures are too noisy and do not serve to quantify the change well.

For the change in monsoon influence, consider the seasonal change in vertical transport strength of the monsoon. For example, your earlier analyses shows that the monsoon uplifting occurred a month before the observations, which suggests that the late August observations may be associated with the late July convective activity, and the late September observations with the late August monsoon activity.

4. Relation to previous work

Although not using CO-O3 tracer correlation, a number of previous works investigated mixing in the lower stratosphere between tropics ad mid-latitudes, including the potential temperature range focused in this paper. In particular the work using STRAT/POLARIS ER-2 data (Volk et al., 1996; Flocke et al., 1999) are very relevant studies. Omitting these works in the introduction and the statement P34775L20-22 give the impression that this is the first such study. Volk and Flocke also showed ways to produce more quantitative transport information in this region.

5. Issues with figures

There is too much repetitiveness in the figures. For example flight 2 O3-CO relationship is shown three times; Figs 5 & 6 are repetitive and so is Fig. 14. In the case of Fig 14, using a "fish born" style of plot (the mean and the error bars) instead of scatterplots would result in much better quantitative information, although I do not think the line of Figs 12, 13, and 14 is the most effective way to bring out the point the authors intended. It is probably more productive to just plot the tracer-relationship and distribution in each flight period and compare the change.

Figure color choices should be done more deliberately so the figures provide the quantitative information for the discussion. For example, the critical levels related to Fig. 5 and 6 are 370 K and 380 K. The continued rainbow color scale does not serve to indicate the trajectory point relative to these two critical levels. Similarly, consider showing clear distinction of above or below 100 ppbv in O3 scale in Fig.10 and the relevant critical values of CO.

6. Technical errors and language problems

- P34770L25: why "in-mixing"?

- P34776L15: "larger 4 and 60 ppbv", check the entire sentence

- P34789L26-27: The meaning of the sentence is unclear. To clarify, consider changing the location of "only" in the sentence.

- P34781L26: "und" -> "and", also in P34806

Additional References

Plumb, R.A., D.W. Waugh, and M.P. Chipperfield: The effects of mixing on tracer relationships in the polar vortices. J. Geophys. Res., 105,10,047-10,062 (2000).

Volk, C.M., et al., Quantifying transport between the tropical and midlatitude lower stratosphere, Science, 272, 1763-1768 (1996).

Waugh, D.W., R.A. Plumb, J.W. Elkins, D.W. Fahey, G.S. Dutton, M. Loewenstein, J.R. Podolske, E. Keim, K.A. Boering, S.C. Wofsy, M.H. Proffitt, K.K. Kelly, C.R. Webster, R.D. May, K.R. Chan, P.A. Newman, and L.R. Lait: Mixing of polar vortex air into middle latitudes as revealed by tracer-tracer correlations. J. Geophys. Res., 102, 13,119-13,134 (1997).

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 34765, 2015.