Atmos. Chem. Phys. Discuss., 15, C11603–C11607, 2016
www.atmos-chem-phys-discuss.net/15/C11603/2016/

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 #3

Received and published: 15 January 2016

General comments:

This paper aims at better understanding the origin of the air masses in the extra-tropical UTLS (ExUTLS). It is based on airborne observations during the TACTS 2012 campaign and on Lagrangian trajectory modeling. The main conclusions concern the seaonal variability between late summer and fall of air masses transport between the "tropics" and the extra-tropics and the difference between transport to the region below and above 380K. Overall, the paper presents new and interesting results that are supported by evidences from the measurements. Nevertheless, the presentation and methodology are rather confusing which weakens the conclusions and I recommend

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some important revisions to address the comments listed below before publication.

Overall, the paper is confusing first because it deals with a number of atmospheric regions such as ExUTLS, ExTL, stratosphere above the ExTL, monsoonal region, asian monsoon anticyclone, tropics, tropical stratosphere, extra-tropical lower stratosphere, which are not enough defined and which may or not be identicals for some of them. For instance, it could be understood that tropical and monsoonal are meaning the same (see comments below) which is not correct. A figure clearly identifying the different regions such as the Figure in in Hoor et al. (2005) would be beneficial to avoid this confusion which makes the understanding of the paper difficult. Using a single terminology for each region would also allow to avoid confusion.

The Asian Monsoon Anticyclone (AMA) is also a key feature of the paper but is not clearly defined and its variability is not properly accounted for. How is it possible to characterize the AMA ? Where is it located and what are its boundariesÂă? Is it present with the same intensity during the whole period analyzedÂă? Without answers to those questions, it appears difficult to draw conclusions about the impact of air masses from the AMA on the composition in the ExUTLS and ExTL during TACTS 2012. The AMA is bounded to the north by the SWJ and to the south by the TEJ. These jets and their intensities should also be documented. The dynamical situation (PV) is only given for the flight 2 of the campaign (Fig 1 a and b) which is not enough. A characterization of the dynamical situation for the different phases of TACTS and of the period up to 50 days prior to the first phase (to account for the 50 days back-trajectories calculations) should be added.

The conclusion about the seasonal evolution of the transport pathways from the "tropics" to the extra-tropics between the end of the summer and the beginning of fall is very general but only based on a two phases campaign during a particular year. The statements should therefore be mitigated with formulas such as "during the year 2012", "based on TACTS 2012 data". For the same reason, the last sentence of the abstract should also be mitigated "the sudy shows that in 2012... from summer to autumn...Âă".

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Detailed comments:

p34769: cite Randel et al., Science, (2010) for upward transport of pollution from the AMA up to the stratosphere via the BDC based on ACE HCN observations.

p34776 L3-10: there is no explanations on why 5 ML were chosen and on how the data points corresponding to each of the ML were chosen. The authors should better explain their methodology to derive the ML.

P34780 L18-23: within the AMA MLS data show that CO vmr is of about 80-100 ppbv at 100 hPa (Park et al., JGR, 2007, 2009) and of 100-140 ppbv at 150 hPa (Li et al., GRL, 2005). CO lifetime in the UTLS is about 2 months. Therefore, if air masses were in the AMA 30 days before being sampled in the ExUTLS, shouldn't they be characterized by CO vmr larger than the 20-40 ppbv measured?

p 34780 L1-5: it is mentioned that air masses rise to 400K with PV>5PVU within the AMA but it is difficult to see where PV values rise above 5 PVU on Fig. 7. From Fig. 5 and 6 it seems that air masses within the AMA stay below about 390K. But the boundaries of the AMA are not defined in the paper. They could be with PV or geopotential heights threshold such as in (REFS).

P 34781-34782: the discussion about the increase/decrease of trace gases concentrations in the ExTL and above is interesting but a bit fuzzy. First, it is not clear why CO increase above the ExTL should be coincident with N2O increase and O3 decrease and not above. Could you develop the arguments about the chemical lifetimesÂă? How much are they different between both stratospheric regionsÂă? The limit of the ExTL should be drawn in order to be sure about what is within the ExTL and above it. Second, it is mentioned that no sign of changes are detectable for O3 and N2O in the ExTL due to their long lifetime. I do not agree, the 3 species display bimodal distribution between the ExTL and above. In the ExTL, enhanced O3 (from green to yellow) clearly coincides with decreased CO. A lower interval for the differences should be chosen for O3 to better see the increase. It is not so obvious for N2O because the color code

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does not really allow to see but colors from green to light blue probably correspond to a decrease.

P 34781 L21-23: in the paper the Asian monsoon region is defined as extending from 20 to 50N and 40 and 150E and Theta > 360K. It corresponds neither to the Asian monsoon identified by convective activity which is limited to South (India, Bay of Bengal) and South East (Thailand, Cambodia...) Asia. Talking about the Asian monsoon above Arabia, Kazhakstan and Mongolia is rather weird. The authors probably meant the AMA region as is mentioned in Fig. 11 caption. In that case, as already mentioned, a correct definition of the AMA should be used. The variability of the AMA is very important even on a day to day basis and no square domain can account for such a variability. This has been shown by Popovic and Plumb, JAS, (2001) (cited in the paper), and Garny and Randel, JGR, (2013) based on PV data. Even on a climatological basis, the square domain that is used is not appropriate. The AMA does never extend to 50N or 150E. Vertically, the AMA is not limited to theta > 360 K as stated in the paper but encompasses the UT down to 300 hPa. Furthermore, the AMA horizontal extension varies a lot between the UT (300 hPa) and the LS ($\sim$80 hPa). In their paper Bergman et al., JGR, (2013) try to determine the origin of the air parcels ending within the AMA. For that purpose they use geopotential heights (GH) criteria such as GH > 16.77 km at 100 hPa and GH > 12.52 km at 200 hPa. Randel and Park, JGR, (2006) use GH >14320 m at 150 hPa. For instance, with the Randel and Park (2006) criterion, for the first stage of TACTS (30 Aug to 5 Sep 2012) the AMA has a single mode and roughly extends from 35 to 115E and 18 to 38N at 150 hPa (which roughly correspond to 360K). 50 days prior to this period (10-15 July) when the back-trajectories start, the AMA is bimodal (with one mode over Tibet and one mode over Iran) and elongated from 5 to 135E. For the second phase (23 to 26 sep), the AMA has largely weakens and partly remains between 80 and 120E. A better criterion based on dynamical parameters (GH or PV) should be used in order to determine if the air masses originate from the AMA.

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P 34783 L21-23: it is stated that "relatively large O3 mixing ratios on a given N2O level should be related to a more tropical or monsoonal origin". P 34784 L 8 "tropical" and "Asian monsoon" are further described as having a similar composition with high O3. Nevertheless, as shown in Randel and Park, JGR (2006) the AMA is an isolated region characterized by lower O3 than the surrounding tropical and extra tropical UTLS. It is also stated that "the highest water vapour mixing ratios at theta = 390K occur in the region of monsoonal circulations". Is this not also indicative of tropospheric origin correlated with higher CO and lower O3 mixing ratios and contradictory with the above statement ? Is it not likely than transport of tropical (outside of the AMA) and "Asian monsoon" air masses are not responsible for the same O3-N2O correlation in the lower extra tropical stratosphereÂă? This point should be clarified.

P34785 L22-25: this point concerning the AMA origin of air masses should be confirmed using better criteria for defining the AMA as mentioned above.

P34786 L1-3Âă: as also mentioned above, it should be clarified wether "monsoonal" and "tropics" younger stratospheric air-masses are responsible for the same N2O-O3 correlations. If "monsoonal" and "tropical" means the same, this should be clear and "tropical" should be avoided.

P 34787 L14-25: the problem of a correct characterization of the AMA also weakens the conclusion of the paper concerning the larger flushing of the stratosphere above 400K in fall that in late summer. Indeed, during the same period the AMA weakens and has disappeared for the second phase of TACTS.

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

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