Review of ‘Long-range transport pathways of tropospheric source gases originating in Asia into the northern lower stratosphere during the Asian monsoon season 2012,” by Vogel et al., submitted to ACPD, 2016

The authors use the global Lagrangian CLaMS model, with artificial and chemical constituent tracers to quantify the contributions of different boundary Layer (BL) source regions in Asia to the Asian Summer Monsoon (ASM) anticyclone, and from there to extra-tropical lower stratosphere (ExLS), for the 2012 ASM season. Further, they illustrate the transport pathways for BL source air, accumulated in the ASM anticyclone, to reach the ExLS, via eddy shedding in the upper troposphere, subsequent filamentation and penetration into the stratosphere, associated with Rossby wave breaking along the subtropical jet. They also consider the westward shedding of air from the ASM anticyclone into the tropical upper troposphere.

The authors use the simulated artificial tracers, and simulated ozone, CO, and water vapor, to interpret small-scale structures observed along aircraft flight tracks as filamentary intrusions of BL source air associated with the ASM anticyclone into the lower stratosphere over Northern Europe. Further, they use the artificial tracers to *quantify* the contribution of different BL source regions to the ExLS over the 2012 ASM season, and use CLaMS simulated water vapor to estimate the contribution of Asian source regions to water vapor in the ExLS.

The study builds upon earlier studies that have illustrated troposphere-stratosphere exchange (STE) mechanisms associated with the ASM, going back at least as far as Dethof et al. (1999), a paper which the authors cite. At the same time the use of the artificial and constituent tracers with the CLaMS model to *quantify* estimates of the contributions from Asian (and other) BL source regions to the ExLS is I believe a step beyond these earlier studies. Quantification of water vapor contribution to the NH lower stratosphere (p.13) is particularly interesting.
The cross-section of the filamentary structure (Fig. 6) provides an illuminating illustration of intermediate (mixed) constituent and stability conditions between the tropospheric and stratospheric air mass characteristics.

The comparison of aircraft observations of the low stratosphere over Northern Europe with CLaMS tracer maps interpolated to the aircraft flight tracks illustrates effectively that the simulation of tropospheric filaments in the low stratosphere represents real-world conditions, and supports the quantitative estimates of
BL source influence in the ExLS presented later. The analysis and interpretation is reminiscent of that conducted by Fairlie et al. (2007) for INTEX-NA aircraft observations; the authors may wish to add correlation scatter plots of the observed O3, CO or CH4, water vapor to further illuminate air mass origin and characteristics of mixed troposphere-stratosphere air masses.

I think the paper could use an editorial review for the English and sentence structure. There is occasional awkwardness in the sentence structure, and some choice of wording that I find confusing, and may be a translation issue (see some examples below).

Nevertheless, I think the paper is suitable for publication in ACP given consideration to these issues and the points listed below, most of which are minor and for the purpose of clarification.

p.6, line 31, What is meant by “Maritime Continent”?

p.7, line 12-13: Comment: The authors will recognize that the transport is only irreversible if the tropospheric intrusion is mixed into the stratospheric surroundings. It is conceivable that an intrusion across the PV=7.2 PVU could return to the troposphere downstream.

p.7, lines 14-15: Comment: I am unable to see the PV=7.2 PVU isopleth enveloping a “region of enhanced tracers”

p.7, line 31, instead of “surface that is” do you mean “surface, i.e.,”? I.e., are the authors stating the definition of “residual” here?

p.7, line 32-33, reference “no signature.” Would the authors be more quantitative here? Looks like up to 10-15% is due to “residual” sources in the anticyclone.

p.8, line 12, reference “indicating transport from the troposphere into the stratosphere.” This is according to the definition of the authors, based on the work of Kunz et al.

p.9, reference discussion of Fig. 9 emission tracer plots, here and elsewhere. Please confirm for the reader if “residual” includes all BL surfaces other than those identified (China/India, SEAsia/ tropical Pacific). How should the reader interpret the sum of these percentages being much less than 100%, e.g. does the remainder comprise background lower stratospheric air, unconnected to any BL surface in past 5 months?

p. 10, discussion of Figs. 9-11. It would be helpful if the authors labeled the locations of flight segments “1”, “2”, “3”, etc. on the maps in Figs. 7-8, to help the reader identify the features highlighted in the flight data to features on the CLAMS maps.
Additionally, the flight data appears to be higher temporal resolution than the CLAMS profiles (e.g. the profile of FISH H2O). It may be helpful to add a time-averaged data profile at the same resolution as the CLaMS for better comparison. Tracer-tracer correlation plots may also be a useful addition (see above).

p. 11, lines 13-15. Suggestion: I think the authors mean to emphasize the locations (Atlantic and Pacific Oceans) here, rather than the mechanism (Rossby wave breaking). They may want to leave out “Rossby wave breaking” in this sentence to keep the stress on the locations.

p.11, lines 18-20. This sentence seems a bit out of context here. Perhaps reference to SE Asia/ Tropical Pacific contribution (the appendix) would sit better after the introduction to Fig.12 (p.11, line 2, after “September 2012”).

p.11, reference discussion of “transport pathways”: The title of 4.4.1 is “transport pathways into the lower stratosphere.” The authors have illustrated that “eastward eddy shedding” on the NE side of the anticyclone, and subsequent transport and filamentation of material can be a pathway to reach the stratosphere (pathway 1, line 10). But, what about the “westward eddy shedding” (pathway 2, line 11) from the anticyclone to the TTL? I find no discussion of this as a potential pathway to the stratosphere, via e.g. diabatic ascent (Garny and Randel, 2015).

p.12, discussion of Fig. 14 and Table 2. Please clarify how these metrics are computed. Are they achieved by area weighting daily isentropic “ fraction of air” maps for areas north of 30^{o}N and for PV greater than the “transport barrier” PV?
Are you saying for example that by end October 2012, almost 20% of the air in the NH at 360K north of these delimiters originates in the India/China BL within the previous 5 months?

p.14, lines 12-14, reference “A mixing layer …. (see Fig. 5)” It is unclear to me what feature is being identified in Fig. 5. I see no discussion of such a mixing layer in earlier discussion of Fig. 5. Indeed 2 lines earlier (p.14, line 11) the thermal tropopause is described as a “strong transport barrier above the separated anticyclone.” Do you really mean Fig. 5? Are you referring to the thin layer of strong vertical gradients in fractions of air and in simulated CO at the thermal tropopause south of ~40^{o}N, ~370-400K)? What is the evidence for mixing, and what is the mechanism? Or do you mean Fig. 6 instead where mixed troposphere-stratosphere characteristics of BL source fractions, CO, and buoyancy frequency *are* evident between the double thermal tropopauses? The discussion of PAN (p.14, lines 16-23) suggest you *are* discussing Fig. 5, but what I see is a strong vertical gradient at the tropopause, not a zone of mixed tropospheric and stratospheric characteristics. I read reference to a “small mixing layer around the tropopause” (p.14, line 33) which seems to minimize the significance of mixing here; if it’s not significant (strong transport barrier), why spend a whole paragraph (lines 10-23) describing it?

There are some places where the English is a bit obscure to me, e.g. on
p.15, line 15, I don’t know what “yield predominantly” means in this context. I wonder if the words “yield to” (e.g. on p.15, line 23) is intended to mean “serves to” or “results in”, i.e. “serves to increase,” or “results in increasing.”

References:

Fairlie, T. D., M. A. Avery, R. B. Pierce, J. Al-Saadi, J. Dibb, and G. Sachse (2007), Impact of multiscale dynamical processes and mixing on the chemical composition of the upper troposphere and lower stratosphere during the Intercontinental Chemical Transport Experiment–North America, J. Geophys. Res., 112, D16S90, doi:10.1029/2006JD007923.

Garny, H., and W. J. Randel, Transport pathways from the Asian monsoon anticyclone to the stratosphere, Atmos. Chem. Phys., 16, 2703–2718, 2016, www.atmos-chem-phys.net/16/2703/2016/ doi:10.5194/acp-16-2703-2016