

Interactive comment on “Long-range transport pathways of tropospheric source gases originating in Asia into the northern lower stratosphere during the Asian monsoon season 2012” by Bärbel Vogel et al.

Anonymous Referee #2

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Summary: In this study the authors examine the transport characteristics associated with the Asian summer monsoon during September-October 2012, using both measurements of trace gases (e.g. ozone, water vapor, methane) and idealized tracer simulations that provide information about the relative contributions of different boundary layer regions to upper tropospheric/lower stratospheric air masses. The study provides strong evidence that the eastward shedding of eddies from the monsoon anticyclone provides an important mechanism for transporting boundary layer air from India and South Asia to the lower stratosphere over northern midlatitudes. While this study provides a comprehensive analysis and important contribution to the field that will make

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it suitable for publication, I have a few major comments that need addressing before I recommend its publication. In particular I have one major concern about the authors' interpretation of the air-mass origin tracers that needs addressing, as it may potentially affect the interpretation of the main results. I also have smaller comments that are, by comparison, less important.

Major Comment:

1) I am concerned about the interpretation of the air-mass tracers as a fraction. It is definitely constructive to look at the relative contributions of different source regions and I commend the authors' use of the diagnostic. However, more care should be taken in the interpretation of the tracer concentration as giving the fraction of air that was last at the earth's surface in a given source region. In particular, the simulation only covers 1 May 2012 - 31 October 2012. If the tracers are to be interpreted as fractions (as the authors intend them to be) then the sum of the air-mass tracers corresponding to all of the source regions must equal 1 (since the union of the source regions is the entire planetary boundary layer (PBL)). This is not the case, however, as shown in Figure 9. The sum of the red, blue and orange lines should, in principle, equal 1 (but does not). What this tells me is that the tracers have not been integrated to equilibrium so that there is a large amount of air that is not accounted for by the source fractions. This is a known issue when dealing with air-mass origin tracers (Orbe et al. (2015)) and I am concerned about what this means for the main conclusions in the study. Please either start the simulation much earlier (to ensure tracer equilibration by September 2012) or remove all references to "fraction" because this interpretation is not correct. Alternatively, it is possible that I am missing something important in the authors' definition of "residual" (by which I interpret the rest of the PBL) – if this is the case, please clarify in the text.

Orbe, Clara, Paul A. Newman, Darryn W. Waugh, Mark Holzer, Luke D. Oman, Feng Li, and Lorenzo M. Polvani. "Airmass Origin in the Arctic. Part I: Seasonality." *Journal of Climate* 28, no. 12 (2015): 4997-5014. (Figure 3b)

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Minor Comments:

1) Line 29, Page 3: I am wary of the use of the term "transport pathways." The air-mass origin tracers only tell you where air was last in contact with the boundary layer. They do not provide a sense for how the air arrived at the receptor location, so please remove all references to pathways. To infer pathways you would need to use idealized tracers similar to those used for inferring the age spectrum or, most appropriately, the path density tracers examined in Holzer (2009).

Holzer, Mark. "The path density of interhemispheric surface-to-surface transport. Part I: Development of the diagnostic and illustration with an analytic model." *Journal of the Atmospheric Sciences* 66, no. 8 (2009): 2159-2171.

2) Line 8, page 6: Again, reservation about the word "pathway."

3) Lines 33-35, page 6: The sum of all of the air-mass fractions does not equal 1, leaving a large fraction of air unaccounted for. Therefore, I am not confident in the statement that "that air masses originating in India/China and Southeast Asia/Pacific Ocean almost exclusively contribute to the chemical composition of the separated anticyclone." Please either start your simulation earlier (to ensure equilibration of the air-mass tracers) or do not use the word "fraction."

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