Atmos. Chem. Phys. Discuss.,
https://doi.org/10.5194/acp-2018-724-RC2, 2018

Atmospheric Chemistry and Physics Discussions

ACPD

Interactive comment

Interactive comment on "Lagrangian simulations of the transport of young air masses to the top of the Asian monsoon anticyclone and into the tropical pipe" *by* Bärbel Vogel et al.

Anonymous Referee #2

Received and published: 14 August 2018

The study "Lagrangian simulations of the transport of young air masses to the top of the Asian monsoon anticyclone and into the tropical pipe" investigates transport processes from the boundary layer to the monsoon anticyclone and further into the stratosphere by employing 3-D CLaMS simulations with mixing and additional backtrajectory data. Further, comparisons with satellite data (MIPAS) are included, which increase the confidence in the presented results. Overall, the manuscript is well written and the figures and analyses are well composed. Further, the study contains interesting results suitable for publication in ACP. Nevertheless, I think that the following comments need to be addressed before the manuscript can be published. In particular, the manuscript would benefit from (and in my opinion needs) an extended discussion of the presented

Printer-friendly version

Discussion paper

results with respect to previous publications.

General comments:

In the abstract and in the text, you distille the transport processes from the boundary layer to the tropical stratosphere into 3 separate regimes. In my opinion, this result is in agreement with previous notions on transport of ASM air massse, i.e. I think it is known that the upper troposphere in the Asian summer monsoon region is strongly affected by convection (e.g. Randel and Park, 2006, show a strong impact from convection at 350-360K), slow upward movement within the anticyclone is addressed e.g. in Park et al. (2007, 2009; see also the schematic Fig. 14 in the latter publication). Further, Ploeger et al. (2017) show slow upward transport of Asian summer monsoon air masses in the tropical pipe (cf. also Randel et al. 2010) and also presents an overview of transport processes in the ASM region in its introduction. There are also other studies addressing transport in the Asian monsoon and some that also mention slow ascent in the UT in the monsoon region: e.g. Wright et al. (2011), Bergman et al. (2012) and Garny and Randel (2016). Nevertheless, it is indeed interesting to have a single study (and model) that shows all of the transport regimes and your study includes additional information. Please, relate your results to these previous findings or suggestions and carve out how your study differs/agrees with the processes described there. How do your results complement these previous suggestions/findings? Maybe you could commet also on the influence of extremely deep (or even overshooting) convection on air masses within the UTLS in the Asian monsoon region.

Related to this issue, you state a convective regime and I wonder how convection is treated in your simulations and backward trajectory calculations. Please incorporate some notion on how the setup of your simulations/trajectories will affect your results.

P.8 L.31-31: "...how can air masses...?": you pose this question, however, to me it is not clear where it is anserwered. Are you thinking about inmixing from the outside to the inside/edge of the AC and subsequent vertical transport. Please connect to the parts in the text where this question is answered and/or e.g. repeat the question and give the answer to it in the conclusion. Would it be possible to include the transport of air masses from adjacent regions above 380K also in your Fig. 13?

Most of the analysis are focused on one day (18 August 2008), only. For some of the analyses this might not be important, however, other analyses might depend on the specific conditions (e.g. the split of the anticyclone) during that date/period as for example the trajectory analysis in Fig. 5. Please include some additional discussion regarding that issue. Partly, you have already addressed this issue, e.g. to complement Fig. 7 you additionally include Figure A1. I would guess that in particular the backward trajectories results are affected by the choice of the starting date and might vary throughout the monsoon season. This issue also extends to the comparison with MIPAS data and to the inferred transport on the eastern/western side of the anticyclone.

Fig. 8 in Garny and Randel (2016) shows kinematic and diabatic vertical velocities and Fig. 12 a) in Park et al. (2007) shows pressure tendencies. These figures show ascent on the eastern side of the anticyclone and descent on the western side at levels close to (but still mostly below) the tropopause. How do your statements and your Fig. 10 relate to that? How does the climatological picture of Fig. 10 look like? Is there always (i.e. on a climatological basis) stronger heating above the western side of the anticyclone above the tropopause but cooling below? How is it on the eastern side?

Additionally, I think it would be very helpful if you relate the results of your tracer pulses shown in Figs. 8 and 9 to the results in Ploeger et al. (2017). In particular with respect to transport of air masses from the anticyclone to the deep stratosphere.

Specific comments:

P1 L19-20: Regarding the effectiveness of horizontal mixing and vertical transport, Garny and Randel (2016) seem to come to a different conclusion. Please discuss (e.g. in Sect. 4) how your results agree and differ. In case of the latter please also discuss why they differ.

P3 L7-10: Regarding the connection of El Nino and La Nina with the Indian summer monsoon. You argue that 2008 was (in terms of rainfall) normal because of La Nina in the winter before, although, in the previous sentence you claim that El Nino and La Nina events tend to be connected to unusual rainfall in the following Indian summer monsoon season. This seems contradictory to me! Further, Kumar et al. (2006) show a relation of concurrent SSTs with rainfall in India (during a quick search I could not find that they are stating a connection with previous winter SSTs). Also, in Webster et al. (1998) I could not easily find to which SST anomaly they refer, i.e. previous/following winter or concurrent summer. Please comment on this and revise if necessary.

P5 L3-5: Is the sum of the tracers for all parcels in the boundary layer really always equal to 1 as you describe on page 5 L3-4. What if unmarked parcels from above the BL are transported into the BL? Are they removed? Otherwise, they might not be marked in the BL as marking takes place every 24h, only. Does the time step of 24h release play an important role? As an example, Bergman et al (2013) use backward-trajectories started every 6 hours. Why don't you mark/emmit the tracer "continuously", i.e. at every time step of the simulation? Is there a scientific or technical reason for this setup.

P6 L1: Please add whether the trajectories described in this section are calculated using heating rates (as I would assume) or kinematic vertical velocities.

P7 L6-9: Has the same method for interpolating MIPAS HCFC-22 data been used in Vogel et al. 2016? Then you could add a note so it is clear.

P8 L16 and following as well as P9 L26-27: Either in the description of Fig. 2 2nd row and Fig. 3 2nd row left or in the discussion you should draw a relation to Pan et al. (2016), who showed that upward transport (e.g. of CO) is mainly focused on the eastern side of the AC.

P10 L13: Please state that you are starting trajectories only on 18 August 2018 for the analyses in Sect. 3.2.1. Or have you analysed other dates as well?

P10 L22-23: How do you know that the transport occurs above the Tibetan Plateau? From Fig. 5 only the longitudinal range is visible but not where in latitude the parcels ascend. If you have made additional analyses to check that they are indeed from the Tibetan Plateau just note that you have analysed this but chose to not include a figure or the analysis here.

P10 L32: At some instances (e.g. here at P10 L32) you refer to inside or outside the anticyclone but do not give a reliable definition or state what you consider as inside or ouside. Would it be an option to include PV contours for that purpose? Also on P11 L5 you should probably rephrashe to "entire Asian monsoon region" because you do not start only within the anticyclone.

P11 L14: Maybe you should rephrase this part stating "At 380..." instead of "Above 380K,..." because at 400K the structures are not as inhomogeneous anymore and above 400K there is also considerable upward transport in the tropics.

P. 12 L14 and L17: Two times 25% instead of ∼15% is mentioned, as I assume would be correct. If I am correct, the 25% are the contribution of the winter pulse (W07) at ∼450K, right?

P14 L6-8: Do you really mean "Asian monsoon air masses from the anticyclone" or rather air masse from your India/China tracer? I think your findings show the claimed relation only for the latter.

P14 L30-31: I think slow upward transport has been proposed earlier (see my general comment). Please clarify if you are referring to some specific point of the upward transport process that was not published earlier.

I think it would be good to label all panels of all figures with (a), (b), (c) and so on as you do for example in Fig. 3 but not in Figs. 4, 5 etc. This is just a suggestion, but would definitely help to increase the readability. Then you could refer directly to the individual panels of the figures and it would be consitent throughout the manuscript.

Also, consider to add additional references to the individual panels in the text when you draw a conclusion or describe something that is based on the respective panel.

Minor suggestions/corrections:

P1 L11: Either change to "Second, these air masses..." or "Second, air masses are uplifted within the anticyclone..." or something similar.

P1 L14: As before, maybe clarify by changing your sentence to something like: "Third, transport of air masses affected by the Asian monsoon (anticyclone)..." or something similar.

P2. L1: This probably needs some additional restriction to where the the Asian monsoon is the "most pronounced circulation pattern". Do you refer here to the tropospheric flow or the UTLS anticyclone?

P2 L21-22: Order references according to year of publication.

P3 L1: Would it be better to change "defined regions" to "specific regions"?

P3 L2: Shouldn't this read: "covering Earth's entire surface". Then it would need to be changed throughout the manuscript.

P3 L32-33: Maybe change to "...a total simulation period of 18 months)."

P4 L2-6: The two sentences starting with "With this approach..." and "This model setup..." seem somehow repetitive. If they are not, please try to clarify.

P9 L4-5: Repetition of "in particular". Please rephrase.

P13 L6: "exists" should be "exist". Also consider to rephrase, e.g. to "... pathways exist. On these horizontal pathways, air masses are transported isentropically..."

P13 L10: I would suggest to shift the first sentence of the paragraph ("On 18 August....") behind the current second sentence ("To analyse...") or/and adapt as it seems to be doubled at the moment.

P13 L33: Probably this should be "...from the tropical...".

P14 L13: Are "Asian monsoon anticyclone" and "Asian monsoon" switched here?

P32: In the caption of Fig. 8 it should state "...(1 May 2007 - 18 August 2008)..." instead of "...(1 May 2007 - 31 October 2008)...", because you show the tracer distribution on 18 August 2008. This is also how you describe the figure in the text.

References:

Bergman, J. W., Jensen, E. J., Pfister, L., and Yang, Q.: Seasonal differences of vertical-transport efficiency in the tropical tropopause layer: On the interplay between tropical deep convection, large-scale vertical ascent, and horizontal circulations, J. Geophys. Res., 117, https://doi.org/10.1029/2011JD016992, 2012.

Bergman, J. W., Fierli, F., Jensen, E. J., Honomichl, S., and Pan, L. L.: Boundary layer sources for the Asian anticyclone: Regional contribu- tions to a vertical conduit, J. Geophys. Res., 118, 2560–2575, https://doi.org/10.1002/jgrd.50142, 2013.

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

Kumar, K. K., Rajagopalan, B., Hoerling, M., Bates, G., and Cane, M.: Unraveling the Mystery of Indian Monsoon Failure During El Niño, Science, 314, 115–119, https://doi.org/10.1126/science.1131152, 2006.

Park, M., Randel, W. J., Gettleman, A., Massie, S. T., and Jiang, J. H.: Transport above the Asian summer monsoon anticyclone inferred from Aura Microwave Limb Sounder tracers, J. Geophys. Res., 112, D16309, https://doi.org/10.1029/2006JD008294, 2007.

Park, M., Randel, W. J., Emmons, L. K., and Livesey, N. J.: Transport pathways of carbon monoxide in the Asian summer monsoon diagnosed from Model of Ozone and Related Tracers (MOZART), J. Geophys. Res., 114, D08303, https://doi.org/10.1029/2008JD010621, 2009.

Ploeger, F., Konopka, P., Walker, K., and Riese, M.: Quantifying pollution transport from the Asian monsoon anticyclone into the lower strato- sphere, Atmos. Chem. Phys., 17, 7055–7066, https://doi.org/10.5194/acp-17-7055-2017, https://www.atmos-chem-phys.net/17/7055/ 2017/, 2017.

Randel, W. J. and Park, M.: Deep convective influence on the Asian summer monsoon anticyclone and associated tracer variability observed with Atmospheric Infrared Sounder (AIRS), J. Geophys. Res., 111, D12314, https://doi.org/10.1029/2005JD006490, 2006.

Vogel, B., Günther, G., Müller, R., Jens-Uwe Grooß, A. A., Bozem, H., Hoor, P., Krämer, M., Müller, S., Riese, M., Rolf, C., Spelten, N., Stiller, G. P., Ungermann, J., and Zahn, A.: Long-range transport pathways of tropospheric source gases originating in Asia into the northern lower stratosphere during the Asian monsoon season 2012, Atmos. Chem. Phys., 16, 15 301–15 325, https://doi.org/10.5194/acp- 16-15301-2016, http://www.atmos-chem-phys.net/16/15301/2016/, 2016.

Webster, P. J., Magaña, V. O., Palmer, T. N., Shukla, J., Tomas, R. A., Yanai, M., and Yasunari, T.: Monsoon: Processes, predictability, and the prospects for prediction, J. Geophys. Res., 103, 14.451–14.510, 1998.

Wright, J. S., R. Fu, S. Fueglistaler, Y. S. Liu, and Y. Zhang (2011), The influence of summertime convection over Southeast Asia on water vapor in the tropical stratosphere, J. Geophys. Res., 116, D12302, doi: 10.1029/2010JD015416.

Interactive comment on Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2018-724, 2018.