

Interactive comment on “Observations of PAN and its confinement in the Asian Summer Monsoon Anticyclone in high spatial resolution” by J. Ungermann et al.

Anonymous Referee #2

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This paper presents spaceborne observations of peroxyacetyl nitrate (PAN) in the region around the Asian Summer Monsoon (ASM) with high spatial resolution. The major focus is to describe the relatively strong confinement of PAN in the ASM and the weaker confinement in an eastward travelling eddy. Further, it is tried to define criteria for the boundary of the ASM and to determine the source regions of the air masses in the ASM. Spaceborne observations of pollutants in the ASM region presented so far have mostly been averaged over longer time periods and had a coarser spatial resolution. Thus, the paper contains new observations that will be of interest to the ACP readership. However, in my opinion the data analysis contains some weaknesses and the wording should generally be improved. Thus, a careful revision is required,

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before I can recommend publication in ACP.

Major points:

I have concerns about the benefits of Figs. 6 and 7 and the related discussion. On the one hand the authors want to point at different strengths of confinement in the ASM and in the eddy, but in Fig. 6 they obviously plot all PAN data versus PV and potential temperature. By means of Figs. 6c and 7 they try to derive criteria to visualize "which air masses are entrapped within" the ASM by inspection of $dPAN/dPV$. As shown in Figs. 4 and 5, both PV and PAN act as dynamical tracers, both having strong gradients at the boundaries of the ASM and of the eddy. Thus, I doubt if the derivative $dPAN/dPV$ is a quantity, which is well suited to determine the boundary of the anticyclones. These doubts are confirmed in the discussion of Fig. 8, where the authors concede, that the curves of maximum gradient $dPAN/dPV$ do not enclose the areas of enhanced PAN or of the anticyclones, but considerably smaller regions instead. Afterwards they resume the discussion of Fig. 5, giving "a better picture of the horizontal transport barriers."

I also have concerns about Fig. 9 and the related discussion. While the vertical red line in Fig. 9a indicating the boundary of the stratospheric branch seems to be appropriate, the threshold for the tropospheric branch at 0.12 ppmv ozone seems to be much too low for the actual data set. The data points in Fig. 9a suggest an at least two times higher value instead. Further, Fig. 9b shows that the major part of mixed air parcels is northward of the thermal tropopause at mid-latitudes. Where do these air parcels come from? From prior eddy shedding, from previous isentropic transport through the ASM boundary or is it tropospheric pollution originating at mid-latitudes?

General remarks:

The authors speak of "isentropes" throughout the manuscript. I think, when discussing horizontal distributions, they should rather speak of "isentropic levels" or "isentropic surfaces" instead.

2. Measurement and model data: The authors emphasise the unprecedented spatial resolution of their measurements as compared to other space borne observations. To substantiate this statement they should specify the along and across track sampling the PAN distribution is actually basing upon.

3.1 Synoptic situation: The authors might give some additional information on previous observations of eddy shedding from the ASM.

P5, L12-15: I do not completely understand how the authors manage to "... improve the measurement density by synoptically interpolating the measurements of multiple days to a single point of time ...". This procedure should be described more clearly.

P5, L25-27: I have also difficulties in understanding this sentence. Please describe the procedure more clearly.

P5, L29f: "The 380 K isentrope is well suited in the given meteorological situation to describe the confinement of the polluted air masses of the Asian monsoon." I do not understand the motivation for this sentence as introduction of Fig. 5, which is a latitude-height cross section.

P6, L12: The authors should add a description of the features visible in Fig. 6b (in case they want to maintain this Figure).

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P6, L29: Does CO really have a longer lifetime than PAN in the UT?

P7, L11-16: This paragraph is somewhat contradictory. First the authors state that "... the thermal tropopause seems to provide a good transport barrier" and afterwards they note that "on the extra tropical side beyond 40°N, one can see elevated PAN VMRs for ≈ 3 km above the thermal tropopause."

P8, L24f: I do not quite understand, what exactly is depicted in Fig. 10. I assume the authors want to show the origin of the air parcels observed on 11 August by use of backward trajectories. They should describe the procedure more thoroughly to enhance clarity.

P9, L11-14: The information in this paragraph is somewhat redundant.

P10, L3-8: This paragraph contains redundant information on the origin of the polluted and unpolluted air masses. Please replace by a more concise phrasing.

Specific comments:

P1, L5: "within the ASM" is redundant and might be omitted.

P2, L2: "... has a major impact on trace gas composition". Please specify, in which regions.

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P2, L5: "It can be found ..." instead of "It can be found in summer ...". It has been mentioned in the sentences before that the ASM prevails during summer.

P2, L30: Please add some more pioneering papers on PAN measurements.

P3, L4f: I think, Glatthor et al. (2007) covered the time period October to December 2003, only.

P3, L6: "... extends our knowledge on the historical evolution of PAN in the UTLS considerably". Considering a snapshot of 5 days, I think this conclusion is somewhat overdoing.

P4, L23: Is "signal-to-noise" ratio the appropriate term in this context?

P6, L12f: "increases linearly" instead of "increases smoothly and constantly", "between around 360 and 400 K" instead of "up to around 400 K".

P6, L18: "decrease of ≈ -60 pptv PVU⁻¹ at ≈ 2.5 PVU".

P9, L17-18: "... the relationship between PAN and PV as a function of potential temperature ..." instead of "... the relationship between PAN and PV as a function of PV and potential temperature ..." ?

P11, eq. A1 and L5: I can not decipher the index of the measurement error covariance matrix.

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Wording:

I am not a native English speaker, but I fear that there are various passages, where the wording is unclear or redundant. Some examples:

P1, L1: "This paper presents a set of observations by the CRISTA infrared limb sounder in low-earth orbit taken in August 1997 and analyses of trace-gases in the Asian Summer Monsoon (ASM) region." is kind of redundant and could be rephrased as follows: "This paper presents an analysis of trace gases in the Asian Summer Monsoon (ASM) region on basis of observations by the CRISTA infrared limb sounder taken in low-earth orbit in August 1997."

P1, L5ff: "Comparing the retrieved PAN VMRs with potential vorticity (PV) on isentropes reveals that the PAN VMRs exhibit the strongest decrease at each isentrope for an increasing value of PV, which may be used to identify the extent of the ASM" is difficult to understand. I suggest "Plotting the retrieved PAN VMRs against potential vorticity (PV) and potential temperature reveals that the PV value, at which the PAN VMRs exhibit the strongest decrease with respect to PV, increases with potential temperature. These PV values might be used to identify the extent of the ASM."

P1, L7ff: "... we also computed the location of the thermal tropopause ... and find that its location agrees well with the limits of the area of increased PAN VMRs both horizontally on isentropes and vertically within the anticyclone." I do not quite understand this sentence. Do the authors want to state that the thermal tropopause confines the area of enhanced PAN towards the stratosphere and towards mid-latitudes? Please clarify.

P5, L31f: "For both PV and PAN, the northern boundary (of what, enhanced PAN and low PV, I assume?) is formed by the jet-stream with strong winds of more than 30 ms^{-1} following (followed by?) a sharp increase in PV (and low PAN amounts north of the jet?)."

P5, L32f: "The southern boundary (latitude) coincides with the thermal tropopause on the isentrope (altitude) close to the equatorial jet". I do not understand this sentence.

P6, L2: "Figure 6a does not show "a scatter plot of PAN VMRs against PV", but rather shows PAN VMRs plotted against PV and potential temperature instead. The same applies for the caption of Fig. 6.

P6, L20f: I do not quite understand, how "the southern transport barrier" (latitude) can coincide "with the thermal tropopause", which is more or less horizontal at these latitudes.

P6, L23f: "Comparing the PV value for the maximum gradient ($d\text{PAN}/d\text{PV}$) at 3.2 PVU with the given PAN VMRs ..." sounds strange. I suggest to rephrase as follows: "Comparing the PV isoline of the maximum gradient $d\text{PAN}/d\text{PV}$ (3.2 PVU) with the given PAN VMRs ..."

P6, L26f: "The PAN VMRs may be not well-mixed enough within the anticyclone, leading to a displacement between the steepest decrease in VMR and the ASM boundary." instead of "The PAN VMRs may be not well-mixed enough within the anticyclone such that the steepest decrease in VMR coincides with the ASM boundary."

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P7, L6f: "This suggests that both the vertical and the horizontal transport barrier is related to the temperature structure of the anticyclone." In which way? I do not quite understand this sentence.

P9, L13-14: "The presented data and analysis provide further observations and evidence ..." is redundant.

P9, L22: "... that air masses are strongly confined within the ASM anticyclone ..." instead of "... that the ASM anticyclone exhibits a strong confinement of contained air ..."

Spelling

P3, L28: "RApid" instead of "Rapid"?

P3, L30: "JUelich" instead of "Juelich"?

P4, L16: "The approximate location of the ASM is located". Please omit "located".

P4, L17: "... a clear separation between air masses of the main anticyclone and of the smaller eastward propagating anticyclonic eddy ..." instead of "... a clear separation of air masses between the main anticyclone and the smaller eastward propagating anticyclonic eddy ..."?

P4, L27f: "which is possible with the configuration" instead of "owing to the configuration"?

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P5, L1: "... which typically is located in the upper part of the anticyclone ..." instead of "... which typically is located rather high in the anticyclone ..."

P5, L2: "... due to the expected strong horizontal gradients ..." instead of "... due to expected high horizontal gradient ..."

P5, L10: "Further note ... " instead of "Note further ..."

P6, L14: "and shows which air masses are entrapped within." instead of "and which air masses are entrapped within."

P8, L19: "... where and when originates ..." ?

P9, L17: "... matched very well to ..." instead of "... was matched very well by ..."

P10, L22: "For the sake of completeness ..." instead of "For completeness sake ..."

P10, L31f: "... deviations in ..." instead of "... deviations of ..."

Figure 1: "exemplarily" instead of "exemplary"?, "... with the precision given as error bars." instead of "... of with the precision figures for this specific profile given as error bars."

Figure 5: "based" instead of "base"

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Figure 9: "the total number of air parcels" instead of "the number of total air parcels"?

Figure 10: "fell below" instead of "went below"?

Figure 11: "passed the altitude of 5 km" instead of "went below 5 km of altitude".

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