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Comment on acp-2022-641

Anonymous Referee #1

Referee comment on "Distribution of cross-tropopause convection within the Asian monsoon region from May through October 2017" by Corey E. Clapp et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-641-RC1, 2022

This is an interesting and important study, which merits its publication in ACP. However the scientific content, the quality of the study and its presentation (in particular the figures) should be further improved. I suggest some major revisions before publication by ACP.

General comments:

1) The quality, the size and the description of the figures should be improved. Some of the figures should be enlarged and it would be helpful to get a more detailed description of the presented quantities (more details see below).

2) In the last years, many publications are published regarding convection in the region of the Asian monsoon. The StratoClim aircraft campaign was performed in Kathmandu (Nepal) in summer 2017 probing air in the Asian monsoon anticyclone conducted in same year as the study by CLapp et al, ACPD, 2022. I think it is worth to discuss some of the results of the StratoClim aircraft campaign in connection to the results by CLapp et al, ACPD,2022 to demonstrate differences and similarities found for 2017 (some of the papers related to StratoClim aircraft campaign are already mentioned by Clapp et al, ACPD,2022 e.g. Legras & Bucci, 2020; Johannson et al, 2020, von Hobe et al., 2021...). There is a special issue to StratoClim in ACP: https://acp.copernicus.org/articles/special_issue1012.html. Here (and also in the references), the authors can find more literature related to convection and vertical transport in the region of the Asian monsoon. I recommend to revise the introduction a bit to give the reader a more comprehensive overview about the topic.

3) It is sometimes difficult to follow the presented analysis. Some more detailed description and motivation would be helpfully for a better understanding (details see below). In particular the wording is sometimes strange e.g.' We identify seasonal trends'.

I think it should be called intraseasonal variability or evolution. A trend would cover a much longer time period (e.g. an increasing trend for OTs occurrence during the last ten years in the Asian monsoon region). I recommend to change the wording throughout the manuscript.

4) The tropopause height is a key parameter for the analysis presented. More details about its calculation and variability should be presented (more details see below).

Major comments:

P1 L22: 'the contributions across the entire region'. Unclear, please clarify this.

P1/2 L25-40:
Convection in the Asian monsoon region is discussed for many years. Therefore several references regarding convection in the Asian monsoon region exists up to now. Please add here some more relevant citations.

P2 L41: 'Satellite observations have shown consistent indications of tropospheric influence in water vapor and carbon monoxide maxima as well as ozone minima concurrent with the Asian monsoon anticyclone that develops in the UTLS region'.

Enhanced mixing ratios of more chemical trace gases tropospheric-origins than H2O and CO as well as of aerosol are found within the Asian monsoon anticyclone compared to the background air in these altitudes. Please revise this sentence and be a bit more comprehensive. This is mentioned later in L46-53. That is confusing, please rearrange these parts of the introduction.

P2 L44: What means 'these perturbations'. Please clarify.

P2 L51: Aerosol measurement in the region of the Asian monsoon is discussed in several publications. It would be fair to add in addition to Vernier et al. some other studies e.g. by Höpfner et al., Nat. Geosci., 2019 (https://www.nature.com/articles/s41561-019-0385-8); Hanumanthu et al., ACP, 2019 (https://doi.org/10.1029/2003JD003770); Brunamonti et al., 2918 (https://doi.org/10.5194/acp-18-15937-2018); Bian et al., Natl. Sci. Rev., 2020 (https://doi.org/10.1093/nsr/nwaa005).There exist even more paper. The authors should decide which references are most suited.

P2 L53: Enhanced VSLS were measured within the Asian monsoon anticyclone in 2017 and their ODPs were calculated (see Adcock et al., JGR, 2021; https://doi.org/https://doi.org/10.1029/2020JD033137)

P2 L54: The authors should add a short explanation of the general upward transport in the region of the Asian monsoon.

P2 L61: 'The location and timing of the initial deep convection influence both the chemical impact of convective transport on the composition of the UTLS and the geographic distribution of that impact.'--> This sounds odd. Maybe better 'The location and timing of the initial deep convection influence the kind and amount of tropospheric source gases and aerosol transported into the altitudes of the Asian monsoon anticyclone (or in UTLS altitudes) .....'

P2 L64: 'therefore which regions are impacted “downstream” in the large-scale circulation.' Please clarify.

P3 L70-79: Many of the cited studies are base on model simulations. In models, different treatments of convection are used (e.g different meteorological reanalyses, different parameterisations of convection) yielding different results. I think this should be mentioned somehow. Further, it would be useful to distinguish in the discussion between studies that are based on model simulations from studies that are based on observations to identify the locations of convective sources.

P4 L117: 'analyzing large scale trends' Please specify, trends of what? (see general comment 3.)

P4 L123: '(see Figure 1c)' -> '(see Figure 1d)'
In the text, first Fig. 1a should be cited. Please rearrange the figures accordingly. I recommend to first show Fig. 1d as a separate Fig. 1 (+corresponding legend, details see below).

P4 L124: 'to allow for comparison to prior work' Please add some references to prior work.

P5 L130: Please add some more recent references.

P5 L139: 'The Indian Ocean region captures and separates the influence of the ITCZ, seen in the OT
distribution (Figure 1a), from the other two regions.' Sentence in unclear, please specify which other two regions. For me it looks like that the Indian subcontinent is located

between the regions with highest OTs occurrence. Add a legend for the regions to Fig. 1d to avoid any misunderstanding. I recommend to show Fig. 1d (+ Legend) as separate Figure 1.

P5 L140: Convection on the northwestern Indian subcontinent was discussed i.a. in Höpfner et al., Nature Geoscience, 2019, as a potential source for the Asian tropopause aerosol layer (ATAL) in summer 2017. I think it is worth to mentioned it here. Further Khaykin et al., ACP, 20022 (https://doi.org/10.5194/acp-22-3169-2022) identified several convective source contribution to air masses probed during the StratoClim aircraft campaign in 2017.

P6 L160: Fig. 1a should be enlarged (e.g show only the dotted-white box). It is good to show the entire Asian monsoon anticylone, however the main regions of OTs occurrence are difficult to see. Maybe it would be better to focus here on the OTs and show the anticylone in Fig.1b/c. Further, something is wrong with the labels at the y-axis.

P6 L163: 'The Indian Ocean shows a high volume of dispersed cross-tropopause convection located at the ITCZ
in an east-west band between 0-5° N. ' This sentence is confusing. During boreal summer the ITCZ is located further north of 0-5° N.

P6 L167: 'This high count of intense convective events has been previously observed' -> 'This high count of intense convective events over the Arabian Peninsula ...'

P6 L167: 'The distribution shows..' -> 'The spacial distribution of OTs over Asia (Fig. 1a) shows ...

P/ L181: I think is worth to mention, that Legras and
Bucci (2020) is also related to the Asian summer monsoon 2017 just as Clapp et al., ACPD, 2022.

P/ L184 '..but the subsequent diabatic ascent into the lower stratosphere occurs primarily in neighboring regions'. Please explain this general upward transport in the region of the Asian monsoon in more detail.

P7 L191: 'Figures 1b and 1c show the OLR minimum and average daily value for the entire study period.' as mean values over the study period from 1 May to 31 October 2017. Yes or trend ?? Please clarify.

P7 L200: 'Figures 1c and 1d show the GPCP maximum daily precipitation and average daily precipitation for the entire study period.' in each grid-box? 'Figures 1c and 1d' --> 'Figures 1e and 1f'

P8 Fig. 2: caption 'Figure 1' -> 'Figure 2'. Please enlarge the height of the panels. It is difficult to see the different lines.

P8 L222: 'For example, the active months of May through August contribute on average 22.9% of the total OTs while September and October contribute 13.4% and 6.3%, respectively.' I can not see these percentages in Fig2. Please explain this in more detail.

P8 L231: I would not call this 'outlier'. Better something like 'OT caused by specific meteorological conditions'

P8 L233-240: The contributions of the different regions is an important result. To highlight this result even better, I recommend to summarize the contributions of different region in an additional table.

P9 Fig. 3: caption 'Figure 1' -> 'Figure 3'. Please enlarge the height of the panels.

P9 L250: --> 'Figure 3 shows the frequency distributions of OTs in 1K intervals for each month related to ...' Yes?
Why is the frequency distributions of OTs shown versus the average and maximum potential temperature of OTs and not versus the the potential temperature itself. Please clarify your choice and explain in more detail how the frequency distributions are calculated? It would be good to show the distance to the tropopause (Fig.3b/d) also in pot. temperature (in K) to make it comparable to Fig. a/c.

P9 L255/257: '...of the pixels within each OT.' --> please clarify 'pixels'?

P9 L264: 'As this trend is present in tropopause relative height as well as potential temperature, it is indicative of more vigorous convection rather than simply being a consequence of the seasonal vertical motion of the tropopause.'
I would call this not 'trend', better 'shift of the maximum of OTs frequency distributions during summer 2017'. Add the mean pot. temperature of the tropopause for each month in Fig. 3a/c to demonstrate the vertical shift of the tropopause from May until October. What is the variability of the tropopause height during one month?
Is the distance to the tropopause calculated for each OT to the tropopause and subsequently the mean distance to the tropopause is calculated or is for each OT the distance to the mean tropopause calculated. Please clarify this point.

P10 L269: 'This is visible in the large number of OTs within the highest bins (337 and 572 OTs for average and maximum tropopause height, respectively), which capture all OTs that reach a height above 2.95 km above the tropopause.'
What is the maximum height above the tropospause of these extreme convective events? This peak at 3.0 km looks odd. The authors should enlarge the x-axis up to the maximum height above the tropopause (shown in level of pot. temperature).

P10 L275: 'seasonal distribution' -> 'intraseasonal distribution'

P10 Fig. 4: Similar question as to Fig.3: Why is the frequency distributions of OTs shown versus the average and maximum potential temperature of OT and not versus the the potential temperature itself. Maybe there is a misunderstanding, please clarify.
Show in addition the distance to the tropoause in potential temperature coordinates.

P11 L96: 'This northward migration is consistent with the expected geographic evolution of the Asian monsoon (Kajikawa et
al., 2012; Romatschke et al., 2009)'. The northward movement of the Indian summer monsoon is known for a long time in India. It would be respectful to cite here also some references from Indian colleagues.

e.g references in Goswami, B. N.: South Asian monsoon, in: Intraseasonal Variability in the Atmosphere-Ocean Climate System, 2nd edn., chap. 2, edited by: Lau, W. K. M. and Waliser, D. E., Springer-Verlag, Berlin, Heidelberg, 21–72, 2012.
I am sure there are more.

P11 Fig. 5: The individual plots are too small. The numbers on the x-axis are truncated.

P11 L311: '... the regions of most frequent cross-tropopause convection are co-located with the most extreme
OLR and precipitation values.' For me is the co-location of OTs and OLR not so evident. Please rephrase this sentence.

P11 L311: 'seasonality' -> 'intraseasonality'

P12 L322: 'This is likely due to the lower tropopause in the earlier months' It would be very helpful for the understanding of the presented results and their interpretation to demonstrate the intraseasonal variability of the tropopause height over the Asian monsoon region.

P11 Fig. 5: The individual plots are too small. The titles are truncated. The arrows indicating the horizontal winds in the bottom row are not visible without strong zoom in. Please enlarge all figures.

P14 L383: 'seasonal trends' -> 'intraseasonal variability'

P15 L387: 'Most of this convection occurs within the Indian subcontinent with North India contributing 29.0% of all OTs, South India contributing 11.7% of all OTs, and the Bay of Bengal contributing 15.2% of all OTs.Together with the Indian Ocean region (19.2%), the most cross-tropopause convection occurs in these regions, and they cumulatively account for 75.1% of all OTs.'
That sounds odd and I don't think that the Bay of Bengal is on the Indian subcontinent.
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'Most of the OTs occurs over South Asia with contributions mainly from North India (29.0%), Indian Ocean region (19.2%), the Bay of Bengal (15.2%) and South India (11.7%) in summary 75.1% of all OTs.' A table listing the contributions of all regions would be very helpful.

P15 L393: 'maximum height of 387 K corresponding to 1.46 km above the tropopause.'
As discussed above I think it is more useful to give the distance to the tropopause in K.

P15 L394: 'seasonal trends' -> 'intraseasonal variability'

P15 L403: 'In the Arabian Sea, most OTs occur in June, with a “hotspot” corresponding to a single
large storm system.' I'm confused in line L374 is written ' is likely sourced from a single large storm system'. Please clarify.
It would strengthen your results if you could demonstrate this is connected (maybe indicating the storm track in your figures) to the storm system or not.

P15 L403: 'Whether these trends in cross-tropopause convection are recurring features should be explored in future
research.' I recommend to remove this sentence. If you draw a connection to future projects, it sounds that your study is incomplete.

P15 L408 'In contrast to prior work that has emphasized either oceanic (e.g. James et al., 2008) or
land-based (e.g. Bergman et al., 2013) convective source regions as dominant, we find that both contribute significant
amounts, though with different seasonal distributions.'

Please clarify: dominant sources of convection impacting the lower stratosphere / the chemical composition Asian monsoon anticyclone or just the occurrence of convection ??

Further, in the last decades there are several studies analyzing possible convective source regions contributing to the Asian monsoon anticyclone, ATAL or the lower stratosphere over Asia. I remember that both different source regions are identified as well as their intraseasonal variability. The authors should discuss this issue more comprehensively including more references. The authors mention already some references in the introduction.

P15 L416-424: I am not sure if this paragraph is an added value for the conclusions, maybe it can be removed or moved to other sections.

P15 L425-435: The authors should revise this paragraph and sharpen their main messages.

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minor comments:

P1 L22: 'the contributions across the entire region' -> 'contributions from different regions' ??

P2 L36: 'are transported' -> 'are transported upwards'

P4 L123: '(see Figure 1c)' -> '(see Figure 1d)'

P5 L139: ITCZ is not introduced

P5 L148: 'OLR' -> 'outgoing long-wave radiation' (avoid shortcuts in titles)

P5 L155: 'and time period' -> 'and time period from 1 May to 31 October 2017'

P5 L154: 'We then compare the distribution of cross-tropopause convection with other convective indicators:' -> 'The distribution of cross-tropopause convection is compared with other convective indicators such as ...'
(two times in succession 'We..' is used at the beginning of the sentence)

P6 Fig.1: 'the total OTs observed in each region' -> 'the total number of OTs ...'

P10 L275: 'Figure 2' -> 'Fig. 2a'