

## ***Interactive comment on “Asian Summer Monsoon Anticyclone: Trends and Variability” by Ghouse Basha et al.***

**Ghouse Basha et al.**

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### Replies to Reviewer #3 Comments/Suggestions

This is a quite interesting paper related to the Asian summer monsoon anticyclone (ASMA) and the title is adequate. The research topic is of scientific interest and worth to be publishable. The study deals with the temporal, spatial and long term trends in the ASMA by using reanalysis and satellite data sets. The authors investigated the decadal variation of the anticyclone region with respect to 1951-1960 base period. They noticed significant changes over the anticyclone edges. Furthermore, the authors also studied the ASMA variability with respect to the wet and dry spells of the Indian monsoon, strong and weak monsoon years, and the stronger El Nino South-

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ern Oscillation (ENSO) years. Overall, the authors have brought out some significant shortcomings from the study. However, I personally think that the paper still needs significant changes before the manuscript is ready for publication. Therefore, I recommend for publication in ACP with revision. I had the chance to read the comments of the Anonymous Reviewer #2 and I do share all his/her general comments.

Reply: First of all we wish to thank the reviewer for handling this manuscript and for offering his/her constructive comments/suggestions, which improved the manuscript content significantly. In the revised version, we have taken care of the reviewers comments/suggestions and we hope the reviewer will find the revised version satisfactory. As per reviewer suggestion, the methodology part and structure of the manuscript is changed compared to previous version.

General comments 1. Abstract needs to be improved. I strongly suggest the authors have to rewrite the entire abstract part and strictly focused on the important results obtained from the study.

Reply: In the revised version of the manuscript, we have changed the abstract by focusing on main results only.

2. How authors define the ASMA region? Why GPH values are considered to define the ASMA region? Other methods are also (for example potential vorticity) used by the previous researchers. Authors can stress this point and define their selection of ASMA region from the GPH values in the manuscript.

Reply: We have mentioned clearly the reason for selecting the GPH values in this study in section 3.1 with complete details and references. 'The spatial extent of anticyclone circulation is clearly evident in the grid 15oN-45oN; 30oE- 120oE at 100 hPa level and the climatological averaged values of GPH varies from 16.5-17 km in NCEP reanalysis during 1948-2016. Using the modified potential vorticity equation, Randel et al. (2006) showed the spatial variation of anticyclone where GPH values are stationary in the range of 16.75-16.9 km. Similarly, Park et al. (2007) showed the anticyclone structure

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from the strongest wind at 100 hPa through streamline function. Bian et al. (2012) reported the spatial variability of anticyclone using 16.77 km and 16.90 km in the GPH contour as the lower and the upper boundary, respectively. Thus, these empirically selected GPH values represent anticyclone boundaries. Therefore, in this present study, we have chosen the values from 16.75 to 16.9 km to investigate the spatial features of the anticyclone’.

3. Why authors separated the ASMA into 4 parts? This needs to be discussed properly.

Reply: In the revised version, we have given following reason for dividing the ASMA into 4 different regions. The spatial trend analysis of ASMA shows distinct variability throughout the region and the edges of the ASMA undergo drastic variability compared to other regions. Therefore, in order to understand the asymmetry in the anticyclone variability, we have divided the anticyclone region into 4 different sectors as shown in Figure 4 based on the peak values of GPH along longitude and latitude cross-sections.

4. Conclusions part looks much generalized. The authors can provide 3 or 4 major results as point by point at the end of the conclusion part.

Reply: During the first review when we submitted the manuscript, one of the reviewers suggested to remove point by point list of conclusions. Therefore, we have written the summary and conclusion part in a paragraph.

5. Finally, the presentation quality needs ‘strong improvements’.

Reply: In the revised version of the manuscript, we have taken care of grammatical mistakes, general statements and other points raised by the both reviewers.

Specific comments: There are some numbers of language and grammar issues in the present manuscript. However, I do not mention all of them in the present review. The authors should take care of all in the revised version of the manuscript.

Reply: In the revised version of the manuscript, we have taken utmost care to reduce the typos and grammatical mistakes to the maximum possible extent.

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Line 7-16: Authors can shift these sentences into the introduction section.

Reply: As per reviewer suggestion, we have sifted some of these lines to the introduction section.

Line 18-19: ‘The decadal variability of the anticyclone is very large at the edges of anticyclone than at the core region’ rewrite the sentence. . .

Reply: In the revised version of the manuscript, we have rewritten this sentence as ‘Significant decadal variability is observed in the northeast and southwest parts of ASMA with reference to the 1951-1960 period’

Line 20: change into ‘to the 1951-1960 period’

Reply: Changed.

Line 22: change ‘anticyclone’ to ‘the anticyclone’

Reply: Changed.

Line 29: ‘. . . .and during strong La Nina years’. Remove ‘during’ from the sentence.

Reply: Removed.

Line 30: Unclear ‘while interpreting the pollutants/trace gases in the anticyclone’ Do you mean changes or variability in the trace gases? Please clarify what is meant here.

Reply: Written clearly in the revised version of the manuscript as ‘It is suggested to consider different phases of monsoon while interpreting the variability of pollutants/trace gases in the anticyclone’

Line 35: ‘from Asia to the Middle East’ – change it as ‘from the Asia to Middle East’.

Reply: Changed.

Line 35: Add ‘The’ in front of ASMA. . .

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Reply: Added.

Line 89-93: data period '1901-2016/1948-2016'. . . . This needs to be clarified.

Reply: Changed the year as per reviewer suggestion. The whole work is done for the period 1951-2016.

Line 94-124: The vertical resolution of GNSS RO data was missed. What is the original resolution of the GNSS RO (CHAMP and COSMIC). Is it originally available at 100/200m or some interpolation is done?

Reply: We have interpolated the data to 200m resolution and added in text.

Line 100-101: I doubt about the vertical resolution of 0.5-15 km? Is it correct? Authors can look on it again.

Reply: Sorry for this mistake. We have changed this in the revised manuscript as 'The temperature profiles from this technique are available with low horizontal (~200-300 km) and high vertical resolutions (10-35 km) with an accuracy of <0.5 K'

Line 112: 'The CHAMP data was available from 19 May 2001 to. . . . ' not required, delete this sentence.

Reply: Deleted.

Line 128-130: rewrite the sentence with clarity.

Reply: Rewritten in the revised manuscript.

Line 132-134: not clear. . . 'The spatial extent and intensity of anticyclone are greater during July compared to the intensities present during other months'. Rewrite the sentence.

Reply: Rewritten in the revised manuscript.

Line 135: Authors can follow any one either 'Asia to the Middle East' or 'Middle East to East Asia' in the entire manuscript. . . . Authors mentioned earlier in Line 35 as 'Asia

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to the Middle East'.

Reply: Thank you for your suggestion. We have followed Asia to Middle East throughout the manuscript.

Line 146: Authors written sometimes as 'anticyclone' sometimes as 'the anticyclone' in the entire manuscript. This needs to be solved in the entire manuscript.

Reply: Changed to 'the anticyclone'.

Line 147: rewrite 'During the September month '

Reply: Rewritten in the revised manuscript.

Line 150: change 'the core region of anticyclone'. . . The core region of the anticyclone.

Reply: Changed.

Line 159-173: The authors presented observed changes in the ASMA region during different decades. This paragraph needs some more discussion on the possible reasons for the observed changes.

Reply: In the revised version of the manuscript, we have added more discussion as per reviewer suggestion.

Line 174-175: I couldn't find 'Figure 3' in the manuscript.

Reply: Figure 3 was merged with Figure 2 in the previous version. However, in the revised manuscript, we have added this.

Line 199-203/Line 263-266: each sentence needs a citation. . . I suggest add some references to the sentences. . .

Reply: References added.

Line 253: 'excited'? It means existed? Check it once.

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Reply: It should be exited.

Line257: This clearly demonstrates that a 'large scale ascent develops over the Asian monsoon region'. Incomplete sentence.

Reply: Modified in the revised version as 'This process clearly demonstrates that a large scale ascent develops over the Asian monsoon region'

Line 258-259: Unclear. Rewrite the sentence again.

Reply: This sentence is edited in the revised version as 'The transport processes from the boundary layer to the tropopause occur on the east side of the anticyclone i.e. southern flank of Tibetan Plateau, northeast India and the head of the Bay of Bengal'

Line 273-274: 'the strongest El Niño (1958, 1966, 1973, 1983, 1988, 1992, 1998, and 2015) and La Niña (1974, 1976, 1989, 1999, 2000, 2008, and 2011) years'. How authors selected these years? The temperature anomalies shown in Figure 8 are from NCEP or GNSS RO? If GNSS RO, how many years considered for obtaining the temperature anomalies?

Reply: We have chosen the strong ENSO years from the website (<https://ggweather.com/enso/oni.htm>). The background temperatures anomalies are shown in the Figure are from NCEP reanalysis data from 1951-2016. We have used only tropopause height data from GPSRO in Figure6, 7, and 8.

Line 307: change as 'reanalysis, satellite and observational data'

Reply: Changed.

Line 308: rewrite the sentence

Reply: Rewritten in the revised manuscript.

Line 309-310: unclear. 'Spatial (magnitude) of the anticyclone structure'

Reply: The spatial extent and intensity of the anticyclone is large during July compared

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to June and August.

Figures: Figure 3 was missed from the present manuscript.

Reply: Actually it was merged with figure 2. In the revised version of manuscript, we have added Figure 3 separately.

Rewrite the title of the Figure 4. . . '1948-2017' to '1948-2016'. . .

Reply: In the revised version, we have written clearly.

Figure captions needs to be improved with more clarity

Reply: In the revised version, figure captions are written in more elaborate way.

Once again, we would like to thank the reviewer for his/her thoughtful comments and suggestions that led to substantial improvements in the revised manuscript.

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