

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

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Replies to Reviewer 2 Comments/Suggestions

This paper deals with the trends and variabilities of Asian Summer Monsoon anticyclone (ASMA) using observational and reanalysis datasets. It deals with the spatial and temporal variabilities of ASMA and its relationship with long term oscillations. The subject dealt with is a very active and relevant topic. However, as I have already pointed out in my initial review, the methodology used for the study and structure of the manuscript needs major revisions.

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

C1

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 according to results.

(1) The authors must bring out the novelty of the study properly. Throughout the manuscript, the already known facts and the results of the present study are in a completely messed up state, for example in the abstract itself. The authors have stated the known facts of ASMA in the abstract. The abstract should focus on the major results of the present study.

Reply: As per reviewer suggestion, we have removed the basic introduction part from the abstract and focused on the mentioning major results of the study.

(2) In the trend analysis, the relevance of dividing the ASMA region into four different sectors is not clear.

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.

(3) What is the sanctity in averaging the wind, when the wind magnitudes are highly inhomogeneous (calm wind near to the centre of ASMA and higher wind to the edges) in all these sectors? Spatial extent of ASMA is discussed in the manuscript. No mention about the altitude/vertical extent of ASMA. This needs to be discussed.

Reply: As mentioned above, depending upon the spatial variability of ASMA, we have divided into 4 different sectors. In order to verify the zonal wind variability in ASMA region, we have selected 3 different locations in Figure R1. At these locations also the

C2

zonal wind anomalies shows significant increasing trend similar to the variability in four different sectors. Figure R2 illustrates the vertical cross section of GPH at these three different locations (Yellow stars). From this figure it is clear that vertical extent is difficult to obtain using fixed GPH. We have also obtained composite mean spatial distribution of GPH and wind vectors at different pressure levels during different months to verify the vertical structure of ASMA (Figure R3). The wind vectors also show anticyclone structure at 200 hPa and 150hPa. However, the spatial structure of GPH extends south at 150 hPa and 200 hPa conversely shifts towards north at 70 hPa and 50 hPa. Clear spatial structure of ASMA can be visible at 100 hPa only.

(4) The study delineates that there is significant trend/difference in the ASMA during different decades during the period 1950-2016. The study period of ASMA variability shown in Figures 6, 7, and 8 are not clear (for active/break days, strong/weak monsoon years, and El Nino/La Nino years). Is it during the period 1948- 2016. The period of wind anomalies and temperature anomalies are not clear from the figure caption (from CHAMP and COSMIC). I think it is better to compare the variabilities for the same period. The ASMA variability for the same period as that of the COSMIC and CHAMP data can be looked into. If already, it is done so, fine. However, this is not clear from the description of the figure caption and in the text.

Reply: In the revised version of the manuscript, we have considered the NCEP reanalysis (wind and temperature) data from 1951 onwards only for Figure 6, 7, 8. Only the tropopause which is shown in Figure 6, 7 and 8 are derived from GPSRO (CHAMP and COSMIC) satellite data which is available from the year 2002 onward only. Compared to previous and other existing data sets, this has the highest resolution and accuracy in the UTLS region at present. Note that major features will not change by choosing different time period in this aspect.

(5) I understand that this manuscript is a part of a special issue 'Interactions between aerosols and the South West Asian monsoon'. However, this aspect is not much discussed in the manuscript. It would be nice if the authors can focus more on it.

C3

Reply: In the revised manuscript we have mentioned it clearly in the introduction and discussion section regarding importance of aerosols and trace gases variability in ASMA. Since the half part of the manuscript discusses the influence of Indian summer monsoon, we have submitted the manuscript to this special issue. Further, we have discussed the variability in trace gases and aerosols in ASMA and their relation with tropopause parameters in a separate paper which is also in ACPD.' Basha, G., Ratnam, M. V., Kishore, P., Ravindrababu, S., and Velicogna, I.: Influence of Asian Summer Monsoon Anticyclone on the Trace gases and Aerosols over Indian region, Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2019-743>, in review. This aspect also we have included in the revised version.

Specific comments: Abstract: Page1 Line 9: 'These pollutants. . .' -restructure the sentence

Reply: Modified.

-Line11-12: 'The pollutants are expected to make a large radiative forcing' Name the pollutants (species) responsible for large magnitude of radiative forcing

Reply: Surface pollutants such as (CO, CH₃Cl). As per reviewer suggestion, the basic introduction lines are removed. The same was suggested by another reviewer.

-Line13: long term oscillations such as

Reply: Long term oscillations are QBO and ENSO.

-Line 19-20: 'Significant.....of the ASMA'. Significant decadal variability is observed with reference to 1951-1960 period. Restructure the sentence.

Reply: The sentence is reframed as 'Significant decadal variability is observed in the northeast and southwest parts of ASMA with reference to the 1951-1960 period'.

Line 21: 'Drastic increase from westerly to easterly'- What does the sentence really mean? (later in Section 3 in Figure 5, it is seen that anomalies are obtained by remov-

C4

ing the mean and strength is obtained by taking the difference of winds at difference latitudinal sectors. In that case is it possible to call the change of sign in anomalies as westerlies or easterlies?)

Reply: Thank you for rising this point. In the revised version we have mentioned it as anomalies.

Introduction Page 2 line 39: "distant maxima characters" Is it a typo error. Did you mean "distinct maxima characteristics" ?

Reply: Yes. We have changed in the revised version as 'distinct maximum characteristics'

line 41: 'The maximum occurs due to strong winds? Rewrite this sentence. The wind in the core of the anticyclone are not strong. Distinct maxima in tracers discussed in next paragraph also. Hence, authors may combine the sentences in first and second paragraph of section 1.

Reply: We have deleted this sentence in the revised version to avoid confusion and combined both the paragraphs.

line 46: modify the word 'issue' find another suitable word ?

Reply: Replaced 'issue' with 'problem'

line 50: 'confined tracers transported outside'- What does this sentence mean?

Reply: We have modified the sentence in the revised version as 'The tracers which are transported are confined in the anticyclone will affect the trace gas concentration in the UTLS resulting in significant changes in radiative forcings (Solomon et al., 2010; Riese et al., 2012; Hossaini et al., 2015)'

Page 3 line 53: delete 's' of Plateaus

Reply: Deleted.

C5

Data and methodology Page 3 line 71: delete 's' of Centres

Reply: Deleted.

Section 2.2: Line 89-93: Specify the real data period used. Whether it is 1901-2016 or 1948-2016?

Reply: The whole analysis was done from the 1951 to 2016. This was clearly mentioned in manuscript.

Results and discussions Figure 3: caption is missing. What is the confidence level of the trend shown? Compared to the trends in the northern end, trend in the southern edge seems to be very feeble?

Reply: Figure caption was overlapped with figure 3. In the revised version of the manuscript, we made it visible. Trends were estimated by using robust regression analysis at 95

Page 8 Line 185: Is it the time series of area/spatial average of zonal wind anomalies?
.....

Reply: Yes. The wording is changed in the revised version.

Line 192: 'contaminated. . . ? '

Reply: We have re-written this sentence with better clarity in the revised manuscript.

Line 193-194: 'One is located. . . and the other in the Reply: These sentences were removed in the revised version as it is creating confusion to the reader.

Rewrite the sentence Figure 5e: Why sector 30°-40° is used. This region doesn't really represent the anticyclone according to figure 4.

Reply: We have followed the same procedure as reported Yuan et al., (2019) for estimating the strength of the anticyclone as difference in zonal winds between northern (30°-40° N) and southern (10°-20° N) flanks of the ASMA. Yuan, C., Lau,

C6

W. K. M., Li, Z., and Cribb, M.: Relationship between Asian monsoon strength and transport of surface aerosols to the Asian Tropopause Aerosol Layer (ATAL): inter-annual variability and decadal changes, *Atmos. Chem. Phys.*, 19, 1901–1913, <https://doi.org/10.5194/acp-19-1901-2019>, 2019. However as per reviewer suggestion, we have estimated the strength of the ASMA by taking difference in zonal wind between northern (22.5 oN-40oN) and southern (10oN-20oN). The modified figure is added in the revised version. It should be noted that, significant difference is not observed.

Page 8, Figure 5: Throughout the trend analysis section, the ‘shift towards westerlies’. Whether the wind is becoming westerly or becoming less easterly (ie, the strength of the easterly is reduced). Whether it is really describing the strength of the anticyclone.

Reply: We are sorry for this mistake. In the revised version, we have mentioned it has zonal wind anomalies instead of easterly or westerly. The strength of the anticyclone was described by Yuan et al (2019) and similar method have been followed in the present study.

In Figure 5, anomalies are obtained by removing the mean and strength is obtained by taking the difference of winds at difference sectors. In that case is it possible to call the change of sign in anomalies as westerlies or easterlies ?)

Reply: Thank you for raising this important point. In the revised version, we used zonal wind anomalies only.

Page 9 Line 204: remove the bracket before ‘during’

Reply: Removed.

Page 9 Line 221-222: whether easterly wind corresponds to cooler regions? Correct the sentence

Reply: Easterly wind corresponds to warmer region. This is corrected in the revised version.

C7

Page 10 Line 237: ‘Further,’rewrite the sentence

Reply: This sentence is modified in the revised version as ‘The composite of mean distribution of the anticyclone circulation during strong and weak monsoon years is shown in Figure 7a based on GPH values at 100 hPa from NCEP reanalysis data’

Page 10 Line 240: In figure 6 the blue doesn’t seem to be weak. The red and blue, strength are same but opposite in direction

Reply: This sentence is changed in the revised version of the manuscript as ‘The circulation expands on the eastern and western sides of the anticyclone during the strong monsoon years (red line)’

Page 10, Line 242: Check this sentence for the correctness of "right (left) side of the anticyclone

Reply: This is corrected in the revised version.

Page 12 Lines 278-281: Check the figures and conclude the features seen in the figure only

Reply: Thank you for your suggestion. We have edited in the revised version.

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.

—END—

Interactive comment on *Atmos. Chem. Phys. Discuss.*, <https://doi.org/10.5194/acp-2019-668>, 2019.

C8

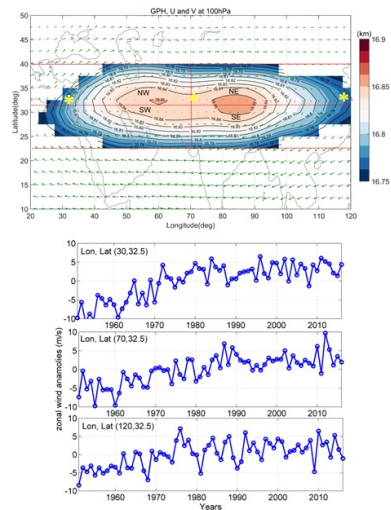


Fig. 1. Figure R1. (Top) Climatology of GPH showing ASMA. (Bottom) Time series of zonal wind anomalies at different locations (mentioned with yellow stars) in ASMA region from NCEP reanalysis data during 1951

C9

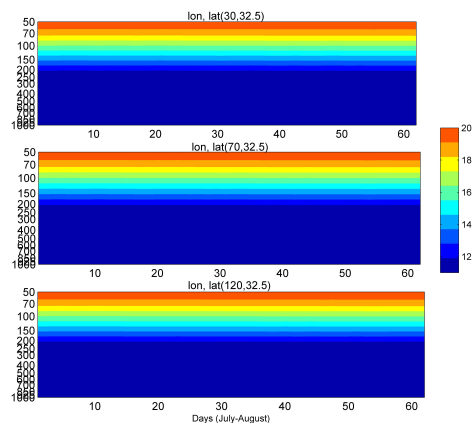


Fig. 2. Figure R2. Vertical cross section of GPH at three different locations

C10

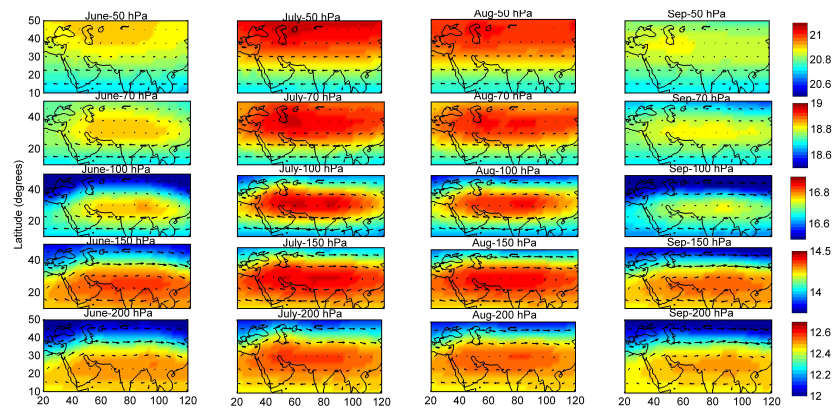


Fig. 3. Figure R3. Composite mean spatial distribution of GPH and wind vectors at different pressure levels during different months.