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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Structure, dynamics, and trace gases variability within the Asian summer monsoon anticyclone in extreme El Niño of 2015–16" *by* Saginela Ravindra Babu et al.

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Replies to Referee #3 Comments/Suggestions

This paper shows the structure, dynamics, and trace gasses changes within the Asian summer monsoon anticyclone (ASMA) in July and August 2015 during extreme El Niño using satellite measurements and NCEP reanalysis data. The spatial extension of the ASMA was quite larger than the mean during 2005-2014 in July and exhibits a strong southward shift. Intense Rossby wave breaking events along the subtropical westerly jet are also appeared in July. For tracers, carbon monoxide (water vapor) decreased by 30% (20%), the ozone increased by 40% at 100 hPa compared to the long-term (2005-

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2014) mean in July. In August, the ASMA splits into two and western Pacific mode. Additionally, the tropopause temperature displays positive anomalies within the ASMA in 2015. The topic of this study is interesting and the authors have presented the results with sufficient analyses. However, some statements in the paper are not precise. The manuscript could be considered to be published in ACP after the following revision.

Reply: First of all, we wish to thank the reviewer for going through the manuscript carefully, appreciating actual content of the manuscript and offering potential solutions to improve the manuscript content further. We have revised the manuscript while considering both the reviewer's comments/suggestions.

Page2 Line 29-31: The last sentence in the abstract is unclear. Please revise this sentence. In the abstract "the spatial extension of the ASMA shows larger than the long-term mean in all the regions except over northeastern Asia", and the last sentence in the abstract "Overall, warming of the tropopause region due to the increased O3 weakens the anticyclone". ... increased ozone weakens the anticyclone?, but the authors mean that the large spatial extension of the ASMA in July 2015ïijit contradict?

Reply: The changes in the O3 concentrations (increase/decrease) within the ASMA are one of the possible mechanisms to strengthening/weakening of the ASMA (Braesicke et al., 2011). By using idealized climate model experiments, Braesicke et al. (2011) clearly demonstrated that the strengthening (weakening) of the ASMA occurred when the O3 is decreased (increased) within the ASMA. The increased O3 within the ASMA warms the entire anticyclone region and weakens the ASMA (Braesicke et al., 2011). Our results from the present study are also in agreement with the results of Braesicke et al. (2011). We also observed a pronounced increase of O3 within the ASMA associated with significant warming of tropopause as well as above and below the tropopause region in 2015. However, to avoid confusion, we have removed that sentence from the abstract in the revised manuscript.

Page7Line152: About the methodology, the authors selected the long-term mean dur-

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ing the period of 2005-2014, why not include the data in 2015 when calculating the long-term mean? Please clarity.

Reply: If we include the disturbed year also while calculating the climatology, it may bias the background. To see the exact variability of different trace gases and ASMA structure in 2015, we have not included the data of 2015 in long term mean.

Page9: For Fig.2, do the authors check the distribution of the GPH using the ERA5 reanalysis data? Based on the results in Nützel et al., 2016, their research shows that only the NCEP reanalysis data show a clear bimodal structure of the ASMA centers compared to other reanalysis data. Curious about the distribution of the GPH from the ERA-Interim/ERA5 data in 2015 and the long-term mean. Additionally, why not calculate the cold point tropopause and the temperature lapse rate tropopause using the same reanalysis data instead of the COSMIC data?

Reply: As for reviewer suggestion, we have tried GPH spatial distribution in 2015 as well as long term mean (2005-2014 mean) by using ERA-5 reanalysis data. The observed GPH distribution was shown in below figure 1 (Note that this figure was not included in the manuscript). We found a clear difference between NCEP reanalysis 2 and ERA 5 GPH in terms of GPH values. But both data show similar spatial structure of ASMA in 2015 as well long term mean.

Regarding tropopause from ERA-5: It is well established that the COSMIC RO is providing high accuracy and high vertical resolution temperature data particularly within the UTLS region. Several studies already have well reported about its usefulness towards tropopause structure and its variability. For this reason, we extensively utilized COSMIC RO data in our study.

Page15: Fig.6 Black arrows can not be seen.

Reply: Apologies for the mistake. We have included the arrows in the revised manuscript.

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Page22L393: This sentence should be rewritten. The tropopause within the ASMA is higher than the outside regions at the same latitude.

Reply: Corrected in the revised manuscript as suggested.

Page26Line477-480: ...enhanced ozone ...warms around the tropopause region and caused an increase in the UTLS temperature within the ASMA...leads to the weakening of the ASMA in 2015. The statement is not clear. The authors mean enhanced ozone warms the tropopause within the ASMA ..and ..leads to the weakening of the ASMA in 2015. If it is true, the results from Figure 3 show that the spatial extension of the ASMA is larger than the long-term mean in all the regions except over northeastern Asia in July 2015 as you mentioned in this manuscript. The authors did not present the connection between the large spatial extension of the Asian summer monsoon anticyclone and the weak monsoon. Enhanced O3 (decrease WV, CO), and positive tropopause temperature anomalies can be seen in July 2015 from your presents, but how the enhanced ozone leads to the weakening of the ASMA in July 2015 can not be seen in the paper.

Reply: The changes in the O3 concentrations (increase/decrease) within the ASMA are one of the possible mechanisms to strengthening/weakening of the ASMA (Braesicke et al., 2011). By using idealized climate model experiments, Braesicke et al. (2011) clearly demonstrated that the strengthening (weakening) of the ASMA occurred when the O3 is decreased (increased) within the ASMA. The increased O3 within the ASMA warms the entire anticyclone region and weakens the ASMA (Braesicke et al., 2011). Our results from the present study are also in agreement with the results of Braesicke et al. (2011). We also observed a pronounced increase of O3 within the ASMA associated with significant warming of tropopause as well as above and below the tropopause region in 2015. However, to avoid confusion, we have changed the sentence in the revised manuscript.

Citation corrections: Page12Line44: The reference Hossaini et al., 2015 is missing.

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Randerl et al., 2010!Randel et al., 2010ïij§Rightïij§

Reply: We have corrected and included the missed references in the revised manuscript.

Page13Line50: ... be found in Santee et al (2017)!... be found in Santee et al. (2017)

Reply: Corrected as suggested.

Page22L389, L396: Ratnam et al., 2016 is missing, or is it Venkat Ratnam et al., 2016?

Reply: Yes. It is Vekat Ratnam et al., 2016. We have modified as Venkat Ratnam et al., 2016 in the revised manuscript.

Page30Line603: Li J. et al., 2008 and Li and Bian 2015 are missing in the main text. ...

Reply: We have removed these references from the list in the revised manuscript.

The citation and references need to be edited thoroughly.

Reply: Thanks for the suggestion. We have taken care about this in the revised manuscript as suggested by the reviewer.

Page9Line188: Fig. 2a and 2b (Fig. 2c and 2d)!Figs. 2a and 2b (Fig. 2c and 2d)

Reply: Corrected in the revised manuscript.

Page14 Line266: 10-6 kg- im2s-2K, correct it.

Reply: Corrected in the revised manuscript.

Page14 Line274-275: Even!even, 04August ! 4August

Reply: Corrected in the revised manuscript.

Page17 Line314: Fig. 7a-c (Fig. 7d-f) show !Fig. 7a-c (Fig. 7d-f) shows

Reply: Corrected in the revised manuscript.

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Page22 Line404: Fig. 10a-b (Fig. 10c-d) show!Fig. 10a-b (Fig. 10c-d) shows

Reply: Corrected in the revised manuscript.

Page25 Line447: Fig. 3 and 4!Figs. 3 and 4 ...

Reply: Corrected in the revised manuscript.

Suggest that the authors should read their final manuscript carefully, or find a proof-reader before the paper was submitted.

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

We once again thank the reviewers for going through the manuscript carefully and offering potential solutions which made us to improve the manuscript content further.

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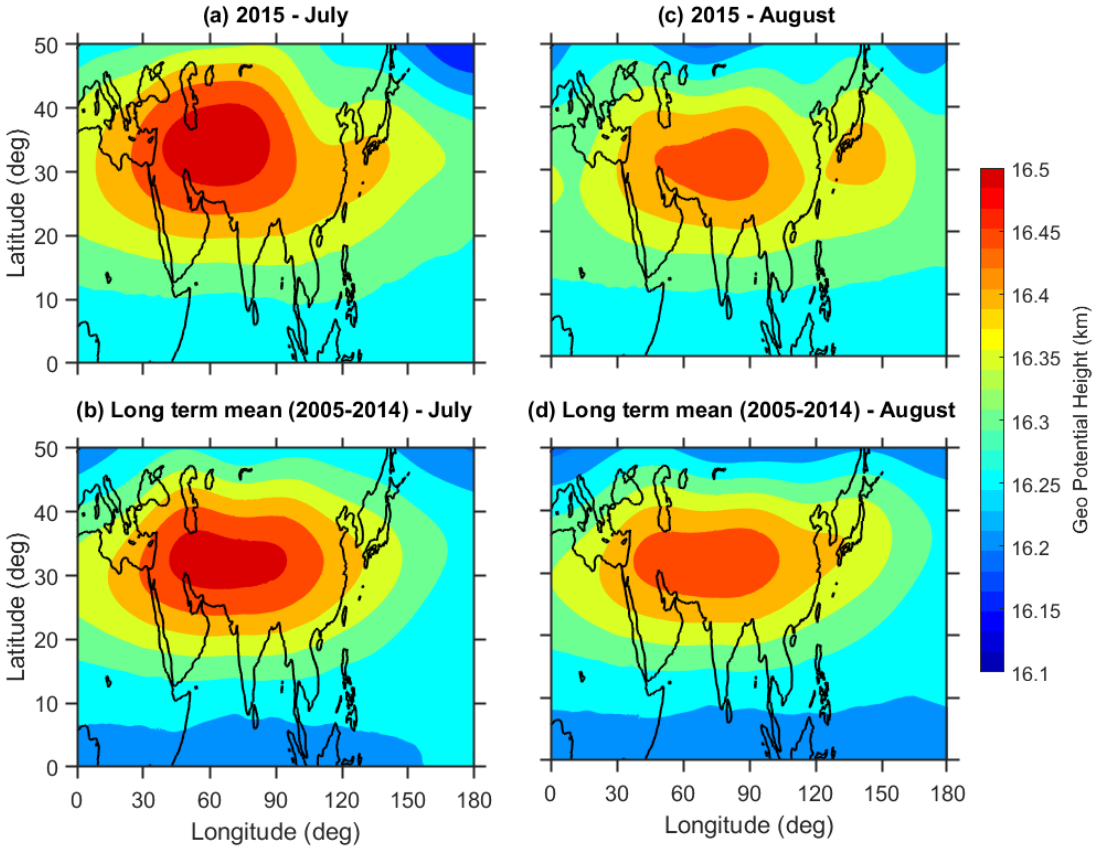

Fig. 1.

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