

Response to referee #1.

We thank the referee for the constructive comments that helped to improve the paper. (Referee comments are emphasized in *italics*.)

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The paper presents an assessment of the representation of the Asian Monsoon Anticyclone (AMA) in the UTLS in the CCM-Val 2 models. The ERA-Interim reanalysis and the MIPAS satellite data are used to compare the dynamical variables and the water vapour and ozone concentrations. The manuscript provides new insights on the abilities and limitations of the models in representing the AMA structure and tracer distribution. The paper is nicely written and the methodology is accurately explained. I recommend publication in ACP after the following minor comments are addressed.

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We thank the referee for this encouraging appraisal of our manuscript. All further questions/comments are answered/annotated in the following and the manuscript is changed accordingly.

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- P5 L14: *This is the first time the terminology JA is used in the main text, explain what it means.*

The terminology JA (July/August) is already explained on page 3/line 26.

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- *Figure 1. In the top panel, showing the winter values of the MIDX is unnecessary and masks the interannual variability in the time series. I would suggest showing the summer values alone in this Figure, in particular the JA indices used for the regressions.*

The updated version of the figure is now showing the time series of the JA average of the MIDX, the Nino3.4, and the QBO, as these are the basis functions used in the multiple linear regression model.

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- P8 L12-13: *Why do you need to multiply the fit parameters by some factor? Also, in Eq. (2) some regression terms are included that are not shown in the paper (volcanoes, trend, solar). Is there a reason to include them?*

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The regression coefficients reflect the change of a quantity, for e.g. JA, by one unit of the respective basis function. To get an estimate of the changes expected by a typical amplitude of the basis function, the regression coefficient is multiplied by a mean amplitude.

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A regression term for the trend should be part of any multiple linear regression model. The regression terms for volcanoes and the solar flux are included in the regression model to capture the interannual variability that potentially emerges by these sources of natural variability. The additional regression terms are necessary to better isolate the signals of the ASM, ENSO and the QBO. The results of the additional regression terms are not discussed in the paper to focus on the most relevant factors.

- *Figure 3 caption: divergence-free zonal wind anomalies*

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Figure 3 is removed from the manuscript.

- P12 L4: *Do you have an idea of why the models have higher water vapour values?*

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These large water vapour mixing ratios can for some CCMs be related to a warm bias in the respective region. But in general this might be too simple as an explanation. Area averaged 360 K ERA-Interim temperature are higher than for the MMOD but MIPAS water vapour maxima (and also ERA-Interim, not shown) in the respective region are lower than the water vapour maximum of the MMOD. We included a sentence about this in the revised manuscript.

- *In the main text Figure 7 is discussed before Figure 6. I suggest that you switch the order of the Figures.*

The order of the figures is switched in the revised manuscript.

- P14 L3-4: *This sentence is not clear, what do you mean?*

5 Between 360 and 380 K dehydration reduces the MIPAS peak values of the H₂O mixing ratios in the ASM region to 7 ppmv at 380 K but this maximum is not as pronounced as at 370 or 360 K. Additional explanations are now included in the revised manuscript.

- P15 L6: *remove comma*

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Done.

- P16 L4-5: *What is the reason to show the 120E-160E?*

15 The region is characterized by a meridional circulation directed towards the Equator, which is a feature of the eastern edge of the AMA. In addition uplift is prevailing, as indicated by the upward arrows. It is also a region where tracers might have been drawn out of the AMA core region. The choice of this region is now better motivated in the revised manuscript.

20 - P16 L24-27: *This sentence is too long, I suggest adding a parenthesis in: (annual average ... monsoon circulation)*

To increase the readability, the parenthesis are included in the sentence.

25 - *Figure 10 and related discussion (P2 L11-14): The main difference in OLR pattern with the Randel et al. (2015) results is in South-East China, where their results show reduced convection over a broad area, and Figure 10 in this paper does not show any significant anomaly. I do not see strong differences in the Bay of Bengal.*

30 The estimation of the strength of the Monsoon in Randel et al. (2015) is based on the OLR anomalies above the southern Tibetan Plateau. Regarding the OLR anomalies above the Indian subcontinent it would be also possible to come to a different estimate.

35 ... *Also, Randel et al. (2015) argue that anomalously cold temperatures associated with strong convection lead to stronger dehydration reducing water vapour in the subtropical UTLS. Do you propose an alternative mechanism? This should be clarified when contrasting your results to those of the mentioned paper. These comments refer also to the discussion on P25 L20-30.*

40 The regression results of the MIDX on temperature also show two regions of lower temperatures associated with stronger ASM (i.e. stronger convection). But rather than located directly above the region of most intense convective activity, as shown by Randel et al. (2015), the regions of cooling are shifted to the north-east and north of the region of convection well confined to the region of anticyclonic circulation anomalies associated with a strengthening of the AMA. A study by Bergman et al. (2013) identified a vertical conduit, located over the southern part of the TP and the southern slope of the Himalayas, where trajectories seem to be concentrated regionally. At lower levels and above this conduit the trajectories spread out to a larger area. If we apply this view to our results of the MIDX regression on ERA-Interim data, it could be possible that the H₂O is preferably transported upward through the relatively warm region at the south-eastern edge of the AMA.

45 - P21 L4: *The positive anomaly is centred on an island in front of the Vietnam coast called Hanai.*

The text has changed accordingly.

References

Bergman, J. W., Fierli, F., Jensen, E. J., Honomichl, S., and Pan, L. L.: Boundary layer sources for the Asian anticyclone: Regional contributions to a vertical conduit, *Journal of Geophysical Research: Atmospheres*, 118, 2560–2575, doi:10.1002/jgrd.50142, 2013.

5 Randel, W. J., Zhang, K., and Fu, R.: What controls stratospheric water vapor in the NH summer monsoon regions?, *J. Geophys. Res.: Atmos.*, doi:10.1002/2015JD023622, 2015.