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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Interannual variability of the boreal summer tropical UTLS in observations and CCMVal-2 simulations" *by* Markus Kunze et al.

Anonymous Referee #3

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General:
Validation of the chemistry climate models CCMs) with respect to their abilities to represent the Asian summer monsoon (ASM), especially the Asian monsoon anticyclone (AMA) is an important task for the atmospheric community. The paper uses MIPAS and ERA-Interim data to validate such CCMs; the comprehensive analysis is clear and well presented. In the second part, the interannual variability of the ASM/AMA system is considered. However, there are some major points which need a more detailed discussion.

Major points:

1. Fig 3 and 4
   Both figures show the results relative to the tropopause pressure that is cer-

   tainly a good idea. You write that in order to account for differences among the CCMs in the location of AMA, the mean anomaly averaged over 30 degree was "centered where the 150 hPA eastward directed divergence free zonal wind maximizes". However, I would like to see such differences in the model representation and would recommend to use a much simple averaging over 120-160E. Maybe you can make two figures for this (you do something similar in Fig 8). Furthermore, the most important information shown in Fig 3/4 are for me temperature anomalies (rather than wind anomalies) which are extremely difficult to read. A compromise could be to show wind anomalies in the absolute range 120-160E and temperature anomalies by using the relative coordinate defined by the wind maximum (and only to mention in the text that such "shifted" wind patterns are very similar for ERA-Interim and the MMOD analysis) .

2. Fig 10 and the discrepancy with Randel et al 2015
   This is a very interesting and important point. However, a simple explanation referring to "different approach" is not enough for me. You can certainly repeat the Randel's procedure by using ERA-Interim H2O (instead of MLS like in Randel et al.). If you get a similar picture ("more convection makes a dry anomaly") than is your statement ("different approach") correct. Otherwise, without such a test you have a "confusing result" if compared with the published work of Randel et al 2015. Furthermore, the paper is in my opinion too long. I would recommend to publish two parts: (1) validation with MLS/ERA-Interim and (2) Iterannual variability. But, that is your decision.

Minor points:

1. General
   In almost all your figures you use a matrix of sub-panels. It would be easier to read such figures if you would denote every row and every column separately. E.g. Fig 5/6 $\theta = 360$ 370, 380 K for the rows and MIPAS/MMOD for the columns.

2. P1, abstract, L14-15
   please mention “zonally asymmetric ENSO response versus zonally symmetric QBO modulation”

3. P1, L24
   first “wave-driven” forcing, followed by heat transport from the tropics to the high latitudes and, finally slow ascent due to radiative heating - please reformulate

4. P 2, L 20-25
   To discuss the importance of the Tibetan Plateau you should also mention the Boos and Kuang, Nature 2010 paper stating that for the formation of the Asian monsoon circulation pattern orography is the most important factor and the impact of sensible heat (Tibetan Plateau) is rather a second order effect

5. P3 L 10-13
   Maybe you should discus it more carefully: the core of the anticyclone is rather in the extratropics than in the tropics. Furthermore, the anticyclone itself acts more as an isentropic blower. Inside of the anticyclone the the tropospheric pollution are trapped and probably transported into the TTL (Randel et al., Science, 2010). Outside of the anticyclone a strong in-mixing of stratospheric signatures into the TTL happens (see related paper from Konopka et al and Ploeger et al)

6. P3 L14
   ...(QBO) or the “internal variability of the ASM iteslf”.

7. P4, L26
   “aspects of the climatological state are compared with” - which aspects, please reformulate

8. P6, caption Fig 1
   please use the abbreviation WIDX

9. P6, L5
   “graduate” - I am not sure that this is a right word. Maybe “mask” or “suppress”

10. P7, L5
    Explain the vector k

11. P9 L2
    Use the notation ψ for the divergence-free part of the flow. Same for χ (which were defined in the previous section).

12. P12 Fig 5
    The enhanced signatures of H2O north of 30N seem to propagate eastward mainly by planetary waves as described by Ploeger et al. Maybe you would like to include some comments about this point

13. P14 Fig 7
    There are much lower temperatures at 380 K for MMOD than for ERA. On the other side MMOD are moister compared with MIPAS. You should comment this point

14. P14 L9
    “O3 in the UTLS can better serve as a passive tracer...” - maybe you can make this point earlier, e.g. as you introduce O3 into your discussion

15. P15 Fig 8
    After the major point 1 was included, Fig 8 would be easier to understand

16. P15 last sentence and P16 first sentence
    This feature was discussed in literature as in-mixing, see Konopka et al 2009, 2010, Ploeger et al 2012. Maybe you would like to include these references into your discussion

17. P17 caption of Fig 7 (and Fig 2)
    You introduced the decomposition given by the eq (1) but you do not use the introduced notation. Please state it explicitly if you show ψ, χ, χ^*, etc.

18. P17 L13
    For me MIDX is a more direct measure of the anticyclone rather than of the whole ASM system

19. P18 Fig 10 and the discrepancy with Randel et al 2015
    see major point 2

20. P19 Fig 11
    I think, you use the ERA-Interim related results too strong as a benchmark for the following investigations. Whereas ERA-Interim temperatures and probably H2O are good enough for your study, ERA-Interim ozone around and below the tropical tropopause is probably not good enough for that (mainly because only O3 column is constrained by sat elite observations as described in Dragoni et al., 2011) . In the following you describe large differences in ozone between multi-model average of the CCMs and the ERA-Interim. I would recommend to exclude completely the ERA-Interim ozone.

21. P20 L7
    "As MIDX is a direct measure of the strength in upwelling" - for me MIDX is a direct measure of the (divergence) of the anticyclone, please re-formulate

22. P20 L9
    ...or have increased H2O or less O3

23. P20 L10
    ...or decreased H2O or higher O3

24. P21 L17
    "The negative O3 caused...." - I do not understand your explanation. Negative O3 anomaly means a stronger tropospheric influence (more upwelling) that is in agreement with the positive H2O anomaly. Please clarify

25. P22 L15
    "unexpected positive response" - see comments above to ERA-Interim ozone

26. P25 L23
    "many regions" - please list these regions

27. P26 L17
    ...suggest transport of H2O through this region

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