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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Stratospheric water vapour and high climate sensitivity in a version of the HadSM3 climate model" *by* M. M. Joshi et al.

Anonymous Referee #1

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Review of Joshi et al., "Stratospheric water vapour and high climate sensitivity in a version of the HadSM3 climate model", submitted to ACPD, 10/6241/2010

OVERALL IMPRESSION: The overall point of this paper is that the version of the climate model discussed has higher climate sensitivity than seen in the AR4 models, with the reason being an apparent unrealistic stratospheric water vapour increase with increased CO2 in the HadSM3 model producing an enhanced stratospheric water vapour positive climate feedback. It does highlight the radiative significance of stratospheric water vapour in the climate system, but does so using a model that produces extremely unrealistic stratospheric water vapour distributions under unchanged CO2 conditions.

The point that stratospheric water vapour is significant for climate is important, and I recommend publication after considering some of the detailed comments below. I think

the paper would be stronger if there were more discussion as to why this particular run results in unrealistic stratospheric water vapour in the present CO2 runs.

COMMENTS: 1) Please give a reference for the "various lines of evidence that support the possibility of high climate sensitivities." (Near line 20, page 6242)

2) Why are the results of the LEP run so different from the standard model? (Page 6243, paragraph with line 10) Intuitively I would expect higher upper tropospheric water vapour if not as much dry air is entrained in convection. However, that should then also have an impact on radiation in the UTLS, and could possibly impact tropopause temperature values (which I would initially expect to be lower if UT water vapour increased). Does it also change tropopause height? Also, what aspects of "this member's climate is in some senses further away from observations"?

3) Some more explanation on why the LEP run doubles to triples stratospheric water vapour is warranted. Are the cold point temperatures higher than in a standard run, or is this due to direct injection of condensed water vapour into the stratosphere? The explanation given on Page 6244 (first paragraph) doesn't fully make sense. Essentially, you are saying that high humidity upper tropospheric air is bypassing the cold point and entering the stratosphere isentropically. That explanation is fine to an extent, but such air will then be in a downwelling branch in the stratosphere, and shouldn't dramatically impact stratospheric water vapour rising in the tropical pipe for example. The results of this paper are implying that such moist air will populate the entire stratosphere. Is that the case, or is it only water vapour in the very lowest part of the mid latitude stratosphere that is affecting the climate sensitivity discussed in this paper?

4) It would be useful to show water vapour for the standard parameter control run and the LEP run (STD1 and LEP1) so that the reader can get a sense of the impact on water vapour from the LEP convective parameterization. (Page 6244, near line 15-25). The text states that the STD results are "broadly consistent with observations", but I personally wanted to see how consistent they actually are. It would also be useful to show

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how the tropical cold point temperatures compare with observations, given that should be a major controlling factor for input of water vapour into the stratosphere. The large hemispheric asymmetry seems to imply that southern polar dehydration processes are having a large impact on the water vapour distribution, as well as input (at least in the LEP1 case) into the 30-60N lowermost stratosphere somehow making it upwards into the middle stratosphere in a region where the Lagrangian mean circulation should be downward. Has there been an attempt to diagnose the Brewer Dobson circulation in the LEP vs. STD models in regards to both temperature and circulation strength to see if that may be part of the reason for the unrealistic stratospheric water vapour values?

5) Page 6245, lines 7-12....my question here relates to the comment in #4 on the strength and direction and of Brewer Dobson circulation...How do you isentropically transport air poleward across the subtropical jet and then lift it into the mid stratosphere via the Brewer Dobson circulation? Is there excessive mixing or numerical diffusion in this model allows air to mix both upwards and equatorward so that it can make it into the tropical pipe region?

6) Page 6245...discussion on radiative processes: the most important point here appears to be that excess water vapour due to the LEP parameterization for convection has a large impact on the climate sensitivity deduced from the model. At what levels is the change in water vapour most important....is it in the stratosphere, or the upper troposphere?

7) Page 6246...please describe (albeit briefly) what the fixed dynamical heating approach is, and perhaps if all the water vapour changes in the FDH model are in the stratosphere; this may answer the question I posed in #6 regarding what levels in the vertical are most important.

8) Figure 2: In Caption: What is globally averaged specific humidity? (Is this valid at a specific vertical level? Is it weighted over some range of vertical levels, was any sort of area weighting applied?)

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