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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.

M. M. Joshi et al.

m.m.joshi@reading.ac.uk

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Replies to reviewer 1- *reviewer comments in italics*

Please see attached PDF for revised manuscript

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

We have changed the wording and added a reference from IPCC (2007)

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?

The tropopause is at the same height, as we now discuss in the text and in Figure 2. The UT region is slightly warmer, because of the extra water vapour. The coarse vertical resolution of HadCM3 is most likely the reason why no change in tropopause height is seen: we now state this in the text. Also, what aspects of this member's climate is in some senses further away from observations? We now state this in terms of RMS statistics, referencing Collins et al (2010), who have carried out such analysis extensively.

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.

We thank the reviewer for pointing this out. We now show that this effect is dominated by the JJA subtropics and midlatitudes, and present plots that show the summer subtropical lower stratospheric vertical velocity is upwards at this location, which can carry the humidity anomaly into the model's stratosphere.

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?

The humidity anomaly is higher in the lower stratosphere, but it is the entire stratosphere's radiative anomaly that affects climate, as shown by the FDH calculations in

the "results section.

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 showhow 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.

We now include plots of the control water vapour and tropical temperature profiles for all four runs STD1, STD2, LEP1 and LEP2, and discuss our results accordingly. We thank the reviewer for focussing on the hemispheric asymmetry- this is a result of upwelling of water in JJA, which we now discuss, with reference to two extra figures. 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?

The temperature of the UTLS region is reasonable in both STD1 and LEP1, as is shown in Figure 2 in the revised text. Water vapour is entering the lower stratosphere in JJA in summer latitudes, as shown in the text now. We would not expect the strength of the Brewer Dobson circulation in HadCM3 to be realistic given the very coarse vertical resolution there.

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?

The model's coarse vertical resolution would explain the diffusion of moisture upwards into the stratosphere- it is simply not well resolved in HadCM3; stratospheric levels lie at approximately 100, 60, 30, 15 and 5 hPa. The Brewer-Dobson circulation is not well represented in this model (see previous point).

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?

It appears to be the stratosphere, from both the FDH radiative calculations, as well as the timescale that the radiative forcing appears on (see discussion and Figure 5).

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.

We describe the FDH method in the revised text; all the FDH changes are indeed in the stratosphere only.

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?)

We thank the reviewer for pointing this out. This is the humidity at 60 hPa: we have added this to the text.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/10/C3739/2010/acpd-10-C3739-2010-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 10, 6241, 2010.