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**Climate of the Past Discussions**

# *Interactive comment on* "Comment on "Using multiple observationally-based constraints to estimate climate sensitivity" by J. D. Annan and J. C. Hargreaves, Geophys. Res. Lett., 33, L06704, doi:10.1029/2005GL025259, 2006" *by* S. V. Henriksson et al.

**S. V. Henriksson et al.**

svante.henriksson@fmi.fi

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Commenting on the four different points:

1. We are able to reproduce the calculation of AH06, but redoing the calculations by taking into account the dependencies between the different sources in a proper way is harder, as the necessary data are not even available to us. Therefore quantifying the error is also difficult, but we will perform sensitivity analysis in point 2 below, by relaxing



or varying assumptions of AH06 that were made without the necessary arguments to back them up.

2. In the following we make a couple of rough estimates of how large the error caused by too simplifying assumptions in AH06 might be. Independence of the volcanic cooling constraint from the two other constraints is harder to justify than independence between 20th century warming and LGM cooling, as has been agreed for instance in the interactive discussion with referee Thomas Schneider von Deimling and also discussed in the original article AH06 to some extent (there it is argued that short-term temperature changes are not accounted for in 20th century studies, but dependencies in transient ocean heat uptake are not discussed). Our first rough estimate will be obtained simply by erasing this constraint from the calculation of AH06 but keeping all other assumptions untouched. This increases the upper bound of the 95% confidence interval to 5.6 degrees, as is illustrated in figure 1. Another option to make an estimate avoiding double-counting data in the 20th century warming and volcanic cooling constraints is to use a uniform prior together with the volcanic and LGM data, as was done in AH06. However, this option is worse since the volcanic cooling source does not account for uncertainty in radiative forcing and therefore obviously underestimates total uncertainty. The remaining estimate based on 20th century warming and LGM cooling is dominated by the narrow distribution from LGM cooling with an upper bound of 6.1 degrees for the 95% confidence interval, compared to the upper bound of 10 degrees for 20th century warming. However, in deriving the pdf of climate sensitivity in AH06 the uncertainty of globally-averaged cooling, radiative forcing and difference between climate sensitivity at the LGM and at the present climate are all estimated rather superficially without any consistent framework. We make a test how much the end result is affected if the bounds of the 95% confidence interval in the LGM estimate are increased by half a degree and thereby the average of the corresponding Gaussian distribution from 1.7 degrees to 2 degrees. The upper bound of the 95% confidence interval in the end result increases from 5.6 degrees to 6 degrees (see figure 1), i. e. almost by the same amount as the change in the pdf from LGM cooling. This shows

that the result of AH06 also largely relies on the assumptions made concerning shape, mean and width of probability distributions corresponding to globally-averaged cooling, radiative forcing and difference between sensitivities at the LGM and at present, that lead to the Gaussian pdf used as the likelihood function corresponding to the LGM.

3. We did not claim that AH09 did not discuss observational analyses in addition to those discussed in AH06 but that AH09 achieves narrow pdfs for climate sensitivity essentially through choosing narrow priors and not through identifying and quantifying dependencies between sources. The notion that some of the problems in the AH06 can be circumvented in certain other kinds of studies is true.

4. See our response to point 2.

Figure 1. Pdf for climate sensitivity (in Celsius degrees) from AH06 (blue triangles), pdf obtained by erasing the volcanic cooling constraint (green solid line) and pdf obtained by erasing the volcanic cooling constraint and adding 0.5 degrees to the upper and lower bound of the 95% confidence level in the pdf corresponding to the LGM (red solid line).

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Interactive comment on Clim. Past Discuss., 5, 2343, 2009.



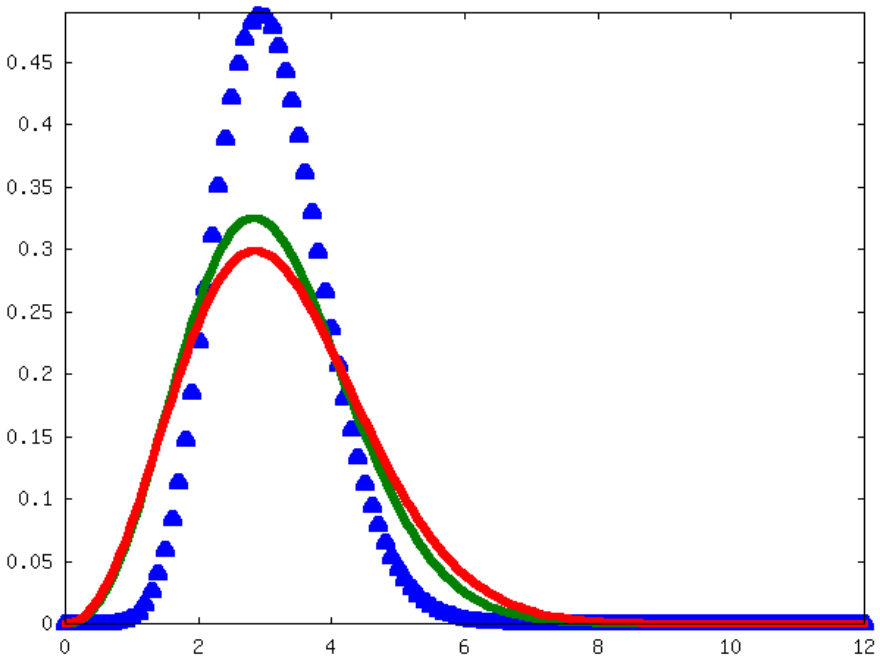


**Fig. 1.**