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Climate of the Past Discussions

Interactive comment on "Could the Pliocene constrain the Equilibrium Climate Sensitivity?" *by* J. C. Hargreaves and J. D. Annan

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First of all, apologies for the delay in providing this review.

Secondly, although I glanced briefly at the comment of Nicholas Lewis, I have not read the other reviews or comments, and so my review below can be regarded as independent.

This paper provides an interesting analysis of whether Pliocene and high-CO_2 modelling combined with Pliocene data can constrain climate sensitivity. The methodological approach seems sensible and well justified.

My main comment is that the range given in the Abstract of 1.8-3.6°C is misleading in my opinion. This is the range given by the 'first attempt', but subsequently additional

factors are considered in the paper which better reflect the true range of uncertainty. These should also be added to the Abstract. Also line 274, I disagree that the "main" result is 1.8-3.6°C. This is an initial result that you then demonstrate to be an underestimate of the range.

Specific comments:

(1) The abstract needs to give a brief description of the methodology.

(2) Line 28. Could also add that in the Pliocene the anomaly goes in the same direction (i.e. warming) as a doubling of CO_2, and so is potentially more appropriate than the LGM for constraining climate sensitivity.

(3) Line 31. Could also add that the Pliocene is an appropriate time period because there has been a huge effort to generate a large observational dataset, mostly by the USGS group of Dowsett.

(4) In the title and abstract and throughout, I am not sure exactly what 'constrain' really means. If the Pliocene could show that climate sensitivity was somewhere between 0 and 10°C, would that be a 'constraint'? I think so. As such, the question posed in the title is rather trivial. I think the real question is 'By how much' could the Pliocene constrain climate sensitivity. Or, do you mean 'Could the Pliocene constrain climate sensitivity to a range narrower than the currently accepted range'?

(5) You state that the Pliocene simulations have probably been carried out for different lengths of time. As such they are at different degrees of equilibrium. This could be partially addressed by accessing the timeseries of temperature in the PlioMIP database and extrapolating the shortest simulations using e.g. curve-fitting to the timeseries, or Gregory plots if the necessary data is available. The lengths of each simulation could easily be obtained if you asked!

(6) Lines 78-95. I confess to not following this section, or even understanding what the issue being addressed is. Intuitively I would think that it didn't matter whether the graph

in e.g. figure 2 was plotted as x-y or as y-x.

(7) Table 1. It is not clear to me that these numbers are completely comparable with the Pliocene equivalents. (i) For the same reason as (5) above – the simulations have probably all been run for different lengths, and (ii) because they may have been run with different versions of the model. Again, this needs to be highlighted and discussed. It might be a good recommendation form this paper that for PlioMIP2 a high-CO_2 simulation is carried out explicitly with exactly the same model and for the same length of time.

(8) I would strongly recommend that you only use the raw point-wise data (70 sites I think) of the PRISM dataset for this analysis. The gridded data used in this paper for evaluation was completely made-up in locations which are far from the raw data (no offence to PRISM!).

(9) Line 160. This seems a little lazy. Modelled SSTs are also in the PlioMIP database, so you should these rather than SATs to compare with the PRISM SSTs.

(10) Line 168. Taking 0.4°C as the initial uncertainty on the data seems over-optimistic to me. I would start with 1°C which is the number often used, and then increase to 2, or even 3°C in the sensitivity studies.

(11) Line 214. Note that the CO_2 proxies only give us CO_2, but there may well be changes to non-CO_2 greenhouse gases, hence why PlioMIP prescribes a CO_2 level greater than many of the proxies.

(12) Line 231. I don't think it's necessarily surprising that zero tropical warming gives a non-zero sensitivity to CO2. Some of the forcings in the Pliocene that given global mean warming (low Rockies, reduced ice sheets) have zero expression in the tropics. See e.g. Lunt et al (2012), Figure 4.

(13) Line 284. Actually, Bragg (2014) did apply the methodology to the Pliocene, and is included in the reference given.

(14) I like the 'data availability' section! Could add where you got the CMIP5 numbers from in Table 1.

Technical comments:

(A) Line 37+38. 'greater' rather than 'higher'?

(B) Line 210. "downscaling" is often used in a different context. Maybe "adjusting appropriately".

Lunt, D.J, Haywood, A.M., Schmidt, G.A., Salzmann, U., Valdes, P.J., Dowsett, D.J., Loptson, C.A. (2012). On the causes of mid-Pliocene warmth and polar amplification. Earth and Planetary Science Letters, 321-322, 128-138.

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