Clim. Past Discuss.,
doi:10.5194/cp-2015-189-AC2, 2016

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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Received and published: 18 February 2016

Thank you for the comments. Here we discuss some of the major points raised.

As a general comment: We certainly share some of the reservations that the reviewer has with the results. There are several challenges with obtaining a robust and credible result, and this analysis with the currently available models and data is intended as a step towards this, rather than a final answer. We did intend this viewpoint to come across clearly in our manuscript (starting with the title) but will try to address this more unambiguously in the revision.

Non-zero intercept: Yes, it is an interesting point as to whether such a substantial intercept is plausible. There are, as discussed in the manuscript, reasons why the line might not necessarily be expected to pass precisely through zero. Natural variability

cannot explain such a large value but a hypothetical model that is globally insensitive to CO2 would not necessarily be regionally insensitive to CO2 let alone different forcings. For example if such a model were to achieve zero mean global temperature change under CO2 forcing by cooling at high latitudes to offset tropical warming, then a warm tropics in the MPWP simulation would be expected. Such thought experiments may not be intuitively comfortable, but we think that is largely because the concept of a model with zero sensitivity to CO2 is hard to swallow. The extrapolation to zero is also quite a way outside the model range such that the linear approximation may fail. However, it is definitely an interesting question as to why the models with lower climate sensitivities generate similar tropical MPWP warming to the models with substantially higher sensitivities. In the revised manuscript, we plan to additionally present results in which the regression is performed with the constraint of a zero intercept.

As for the nature of the regression: We do not see why the larger fractional spread should determine the direction of the regression. It is certainly simple to generate artificial examples where this is not the case, as the direction of the regression depends on whether the residuals are independent of one variable or the other as discussed in the paper. For any regression on data (Xi,Yi) it is always possible to define the ratio Yi/Xi for each pair of points, but this does not tell us anything about the regression residuals. We do not believe that residuals would necessarily be zero for zero sensitivity models, which would make multiplicative errors inappropriate.

It is indeed notable that the estimate arising from the data lies very much at the end of the model range, though clearly overlapping it when realistic uncertainty is taken into account. One possible explanation of this is that the forcing due to boundary conditions (particularly CO2) may be excessive - a value as low as 350ppm CO2 is also regarded as quite plausible and would result in a much better agreement between models and data (according to our simple adjustment presented in the manuscript). Additionally, the data used in PlioMIP do not represent a true time slice, which makes it hard to be confident in a direct comparison with model simulations, even assuming that the

calibration of the data points was robust (which history suggests may not be the case). The next iteration of PlioMIP, focussing as it will do on a specific time slice within the MPWP, should provide clearer results.

As for the treatment of the uncertainty in the Pliocene SST data, we would be open to any helpful suggestions. We didn't do any processing on the data ourselves, but simply used what has been published, for which no uncertainties have been provided. We have discussed this with some of the scientists responsible and decided that the most appropriate way forward was for us to at least test the sensitivity of our results to a plausible range of uncertainty values. We hope that the data analysis will be more quantitative in future, but the current state of the art is as reported. We think it is useful to investigate the sensitivity of the results to a reasonable range of uncertainties on the data.

We will reply to the detailed comments in the formal response to reviewers.

Interactive comment on Clim. Past Discuss., doi:10.5194/cp-2015-189, 2016.