Clim. Past Discuss., 8, C1910–C1913, 2012
www.clim-past-discuss.net/8/C1910/2012/

Climate of the Past Discussions

Interactive comment on "Estimate of climate sensitivity from carbonate microfossils dated near the Eocene-Oligocene global cooling" *by* M. W. Asten

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Received and published: 15 October 2012

Author's Reply to Interactive comment on "Estimate of climate sensitivity from carbonate microfossils dated near the Eocene-Oligocene global cooling" by M. W. Asten

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I thank Prof Pearson and colleagues for their comments. I have acknowledged their work (Pearson et al, 2009) in the past and acknowledge it again here as an excellent work with a data-set placed in the public domain which has made my effort at estimating an Oligocene climate sensitivity possible.

In Pearson et at (2009) the authors refer to carbon-cycle modelling and note the discrepancy of observed pCO2 increase over 50K years versus the modelled time required for that increase of 500K years. This is a substantial discrepancy which I believe deserved greater recognition than was accorded to it in Pearson et al (2009). In the current discussion Pearson et al (2012) amplify their arguments and provide a list of factors affecting CO2 , global and local temperatures. In particular they state "our [pCO2] record is broadly in agreement with this state of current understanding although the timing of some features remain difficult to explain." Again, I regard this last statement as a significant understatement given that "timing" shows an order of magnitude difference between observation and modelling.

I cannot resist quoting an observation from Nobel prize-winning physicist Richard Feynman, "It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong."

Disagreement on the interpretation in no way downplays the quality of the sampling analysis and interpretation which went into building the pCO2 data set. We can thus proceed by accepting the validity of the detailed pCO2 data set compiled by Pearson et al (2009) and ask what alternative interpretation might be drawn from that data. The time of 50K years given by Perason et al for the pCO2 increase is geologically very short (although long enough that equilibrium conditions in pCO2-temperature relations may be assumed unless specific new data points to a contrary conclusion). The time length is sufficiently short that we may assume significant tectonic change would not occur in the duration of the observation. The measurement time is placed at a post Eocene transition time where we can accept the important tectonic change of the opening of the Antarctica-South America ocean has occurred (thus allowing circumpolar ocean currents), and It is therefore inescapable that we must ask the question, what do we see in the global temperature and pCO2 record at his geological instant of time. Accordingly, I have asked the question in Asten (2012) and, subject to a range of assumptions and caveats, I have an answer which I have submitted as an addition to the existing literature of paleotemperature estimates of climate sensitivity, all of which are similarly subject to debate on the merits of their associated assumptions and caveats.

On the problem of quantifying the change in pCO2, Pearson et al (2012) write "the difference in CO2 (delta-pCO2) between the rebound and the surrounding values (using the data tabulated in our Figure 1) is from as little as 77 to as much as 638 ppm." Pearson et al make two quantitative mistakes in their comparison here while admitting that their calculation is just an exercise, not a serious estimate. Firstly they use 95% confidence limits, whereas my calculations use 66% confidence limits (as do the IPCC and the majority of referenced papers since 2007 when tabulating values for climate sensitivity). Secondly they compute baseline and higher values by addition and subtraction of the 2-sigma values for an individual point. Even though we have a limited data set it seems sensible to use statistical formulas for reduction of variance when averaging two numbers (whether for baseline or higher value) and addition of variance when differencing the higher value and baseline value.

Finally, Pearson et al (2012) claim that my use of a relation between deep-ocean temperature and global mean temperature is invalid. In their discussion they quote results from Robinson et al (2011) which show that various shallow, mid and deep-ocean holes yield temperature records indicating varying differences between Pliocene and modern ocean temperatures. The argument offered by Pearson et al (2012) in relation to this discussion is a straw-man argument; the issue is not whether deep-ocean temperatures in the Pliocene track modern deep-ocean temperatures, but rather whether deep-ocean paleotemperatures tracked global average temperatures at the time of the sediment formation. Asten (2012) does not argue evidence for the latter but rather quotes two authoritative sources (Kohler et al, 2010, Figure 8; Hansen and Saito, 2012, Figure 2) as examples showing that the correlation between deep-ocean temperature and contemporaneous global mean temperature is strong for Pleistocene measurements other than during times of deep glaciation. Those sources are of course open

to challenge in other publications if and when appropriate data is produced.

In the absence of similar deep-ocean to global temperature data for the Oligocene, but recognising the similarity of continental and ocean positioning between the Oligocene and later geological times and the lack of deep glaciation in the Oligocene, I argue it is reasonable to postulate a similar relationship and proceed to estimate a value for Oligocene climate sensitivity.

At the end of this study it has to be recognised that this is only one temperature data point (hole 744) with weak support from hole 522, and one geological formation (Kilwa, Tanzania) for pCO2 estimates. I expect that other data sets will come, and the assumptions in this study will be tested. In the meantime this Oligocene event, like its often-quoted PETM equivalent, provides useful data for discussion on climate sensitivity and the possible role of various feedbacks.

Reference

Robinson et al.: Bathymetric controls on Pliocene North Atlantic and Arctic sea surface temperature and deepwater production. Palaeogeography, Palaeoclimatology, Palaeoecology, 309 (1-2), 92-97, 2011. (Other references are as provided in the Discussion Paper)

Interactive comment on Clim. Past Discuss., 8, 4923, 2012.