Climate
of the Past

Open Access

EGU

Discussions

Interactive comment on "Stripping back the Modern to reveal Cretaceous climate and temperature gradient underneath" *by* Marie Laugié et al.

Alexander Farnsworth (Referee)

alex.farnsworth@bristol.ac.uk

Overview:

This paper attempts to deconvolve the impact of four different boundary conditions (carbon dioxide, ice sheets, solar luminosity and vegetation/soil parameters) on the climate and temperature gradients of the Late Cretaceous to understand their relative roles. Through the use of the IPSL model a series of simulations are performed with changing the model boundary conditions in a step-wise fashion through introducing each one until a fully Late Cretaceous is simulated from the Pre-industrial.

They find that CO2 has the largest impact on the climate signal, but also signify that paleogeography also plays an important role in perturbations in the pole-equator temperature gradient though changes in ocean circulation and feedbacks.

General comments:

This is an interesting study using an updated version of the IPSL model looking at the long standing issue of equable climates of the past problem. I like the experiment design used within this study, it nicely deconvolves the different boundary conditions being investigated in a somewhat clean manner. Although it is, as I am sure the authors well know, more difficult to identify the direct and indirect influence of the non-linear feedbacks that can also occur without a full suite of simulations looking at each boundary condition individually/in pairs in a matrix style approach.

Although the issue is still present this work does provide some interesting results and what influence each boundary condition investigated has on the general climate and the pole-equator temperature gradient.

I think this study should be published and I look forward to being able to reference it, however I do have some comments that may help improve the manuscript before publication.

âĂć Why should the Cenomanian-Turonian thermal maximum be of more relevance than that of the PETM, MECO, etc. to the future. Worth while to flesh out why this particular time period is deemed important âĂć There will also be non-linear feedbacks that cannot be deconvolved with the current methodology. I.e. The proportion of landmass at different latitudes between the pre-industrial and Cretaceous at Preindustrial CO2 levels (and topographic height differences) will have a dissimilar impact on the vegetation response and in turn the warming response from increased CO2. âĂć I did sometimes get a bit confused with the methodology section. It was sometimes hard to see what models were initialised with what initial conditions. How were some of the boundary conditions treated. i.e. what were the actual albedo prescribed? Was the

vegetation uniformly applied even to mountain regions where it may not grow? Might be worth being a bit more concise in describing them individual boundary conditions and how they were implemented for clarity and reproducibility. âĂć Minor point. Some of the use of English could be improved in places, however this is fairly ancillary and does not in any way detract from the good science being shown. âĂć Page 5 – Line 40. It looks like only the 1X-NOICE is in equilibrium in the deep ocean. The other four still appear to be trending. I think for clarity this should be stated or changed to "near-surface equilibrium". I certainly sympathise as some of my own simulations can take up to 10,000 model years to reach equilibrium. However, I do not think this will change the overall results, but for clarity it should not be stated as complete equilibrium. Gregory plots may also be another useful diagnostic to see if you have an energy imbalance otherwise. âĂć Ice sheet removal impact. I agree with your assessment of the regional impact, however it might also be that you get a pseudo ice sheet in the 1X-NOICE simulation with perennial snow cover over the soil surface, just a low elevation one. I suspect this is the case as in the 4X-NOICE you get a much large response in the change in surface and planetary albedo. Did you ever run a 4xCO2 experiment with ice sheets in the pre-industrial to see the relative impact of just the CO2? âĂć Do you see any change in ocean circulation patterns from removal of the ice sheet and increased CO2 in the preindustrial?

Minor comments:

âĂć Page 1 & 2 – Line 17 & 33. 'period' not "era" âĂć I think it is worthwhile to define what you mean by 'high' and 'low' latitudes as you often see different values purported in different studies for clarity. âĂć Throughout – put references in chronological order. âĂć Page 2, Line 60. Define "P.A.L." here. This is the first instance in the ms rather than on page 6- line 50. âĂć Page 3 – Line 79. Change sentence to "the primary driver of Cretaceous climate has been suggested". âĂć Page 3 – Line 83. Delete erroneous "s". âĂć Page 4 – Line 96. Probably more accurate to say "We performed six simulations using both Pre-industrial and Late Cretaceous boundary conditions where we

incrementally modify the Pre-industrial boundary conditions to that of the Late Cretaceous for. . . . . .1,2,3,4". âĂć Page 4. Although stated that IPSL-CM5A2 has been used for contemporary and future climate simulations it would be worth adding a line that states how well the model performs in simulating a modern-day climate. âĂć Page 5 – Line 20. Repetition of "long" in the sentence. Remove one of them. âĂć Page 5 – Line 37. "retreat" to retreat. But I think 'removed' would be more accurate. âĂć Page 6 – Line 53. Is that from the 4X-NOICE simulation? âĂć Page 6 – Line 218-222. Did you look at atmospheric stability arguments in relation to this? âĂć Page 6 – Line 223. Do you mean greater season ice melt or there being less sea ice area in the 4X-NOICE compared to the 1X-NOICE simulation? âĂć Page 12 – Section 3.5.1. The percentage change adds to 99%. Rounding error? âĂć Page 12 –Line 321-324: There does not appear to be any change in the N.Hem SST gradients (0.45/lat). Any idea why? You attribute the Greenland ice sheet/sea ice for less sensitivity in the atmospheric gradient of the N.Hem. Something similar here? âĂć Page 14 – Line 370. Do you mean that you used the Tabor, et al. dataset and adding more data points to it? âĂć Page 14 – Line 388. Only if you suggest there is a seasonal proxy bias. This is mentioned later on, but might be worth a few ref's that show there are seasonal bias in some proxies. âĂć Page 16 – Line 448. Do you mean 'more complex' rather than "large"? âĂć Page 17 – Line 480. "cloud" not "clouds". âĂć Page 17 – Conclusions section. This is a tad bit repetitive of the results/discussion. Perhaps broaden this out with respect to the discussion in your introduction. âĂć Figure 1, 5,6, 8, 9, 11 Captions. Add 'mean annual' to caption. âĂć Figure 2. Is that the model resolution geographies? âĂć Figure 11b. Appears to be some modelling studies missing? E.g. HadCM3L 2xCO2 data point and others. Or was I interpreting this wrongly? Quite possible!

Best, Alex Farnsworth