Clim. Past Discuss., 9, C365–C369, 2013
www.clim-past-discuss.net/9/C365/2013/

Climate of the Past Discussions

Interactive comment on "Albedo and heat transport in 3-dimensional model simulations of the early Archean climate" *by* H. Kienert et al.

Anonymous Referee #2

Received and published: 8 April 2013

Kienert et al: Albedo and heat transport in 3-dimensional model simulations of the early Archean climate.

Recommendation : reject but encourage re-submission.

This manuscript highlights the impact of the albedo and heat transport on the early Earth climate for different pCO2 (0.4, 0.6, and 0.8bar). The sections 3.5 to 4.1 are clearly the most interesting parts of the manuscript and are potentially important to understand the effects of the ocean dynamic on the early Earth climate (faster rotation rate, a reduced continental crust, ...). This study demonstrates that in warmer conditions, a supposed characteristic of the early Earth climate, the meridional heat transport tends to decrease, the oceanic overturning being partially governed by the absence of continents. If this paper has the potential to become a valuable contri-

bution, this manuscript will require several major improvements before it is ready for publication. The main issues are:

Scientific interest

The scientific relevance of this paper must be defined more clearly. Moreover, results described in the section 3 are partially published in Kienert et al. (2012). To improve the paper, a very significant rewriting is necessary. The paper should be focused on the ocean dynamic (unfortunately too shortly discussed in the present version of the manuscript). A second problem concerns the systematic comparison with the pre-industrial climate. The comparison with pre-industrial climate does not appear, in most of the sections, relevant to decipher the effects of the albedo, topography, CO2, or of the faster rotation rate. Indeed boundary conditions, between a pre-industrial run and an early Archean run, are clearly too different to be easily compared. To explore the potential impact of each factor, sensitivity experiments should be conducted by replacing one element of the reference run (ex : EA, pCO2=0.6bar). Hence, the new version of the manuscript should contain sensitivity runs showing (1) the ocean dynamic behavior as a function of the Earth's rotation and (2) the oceanic dynamic behavior as a function of the topography. This addition is needed because major results concerning the effects of the CO2 are already published in Kienert et al. 2012

Presentation of the manuscript

The manuscript is well written but not easy to follow because the text is not well organized. Indeed the section 3 associates results along with discussion. That disrupts both the reading and the argumentation (ex: section 3.1.2). Results and discussion must be separated in distinct sections. A section about results must clearly announce new findings. I also suggest that the section 2 includes a paragraph and a table in which the set of simulations performed will be clearly presented. The literature review is up-to-date albeit some references to previous work (especially Jenkins and al.) must be added (ex: line1 p540). The new version of the manuscript should refer more clearly

to these previous studies (i.e Jenkins 1993, Jenkins et al 1993).

Suggestions to improve the manuscript

In addition to my general comments, I make some recommendations that the authors may consider to improve the paper.

(1) p527 line 8-10 “A few early studies of the Archean climate (Jenkins, 1993, 1996) have applied 3-dimensional models but were highly simplified (e.g. without a full ocean model).”

I disagree with the sentence (notably “highly simplified”). The authors have to demonstrate why the AGCM used by Jenkins (1993) seems to be simpler than an EMIC (here CLIMBER3).

(2) At the end of the section 2, please add a table wherein you will present the numerical experiments you performed (in the manuscript a part of simulations performed are described in sections 3.1.1 and 3.1.2, so after the first results).

(3) A very useful addition to this work would be to simulate the climate using Jenkins’ boundary conditions published in 1993 (i.e no land, solar constant=1233W.m-2, and pCO2 = 330ppm and 2640ppmv) to compare climates simulated by CLIMBER and an AGCM (the real-time computing to perform this new set of simulations should be reasonable).

p529 lines 16-18 “In total, the model simulates approximately 200 model-years per day of integration on a single CPU, which makes it possible to perform a large number of ensemble simulations until they approach equilibrium after 5000 yr in this study.”

However I realize that the authors may not want to undertake this comparison I have outlined. In that case they should better explain the agreements/disagreements with the conclusions of Jenkins concerning the early Earth climate. At the first order, the authors could assume that the CLIMBER run EA, pCO2=0.6bar corresponds to the run SCRC (Jenkins 1993). Do the same with the run EA, pCO2=0.4bar and the run SCR

(Jenkins 1993).

(3a) section 2.2.4. Results in agreement with Jenkins et al. (1993), please refer to this study

(3b) fig.5. 8. 10. 11. 16. These results could be compared with Jenkins’ results (1993)

(4) p536, line 19 – p538, line 11. Results already published in Kienert et al, 2012. I suggest to rewrite or remove this part.

(5) p540 – lines 12-18. The authors must explain why the impact of topography on the sea- ice decreases (PD to EA) when the rotation rate increases (table 2) ?

(5bis) table 2. Add the clouds response and all boundary conditions used

(6) fig.6 (and fig.19a). The authors must explain how the surface albedo could be higher than the planetary albedo (fig.6 see blue and green curves in high latitudes and fig.19a red, blue lines below 265K).

minor points

(7) p528 lines 9-12 “In the early Archean, the emerged surface area was much smaller than today (Flament, 2009) so that similarities in the dynamics of the climate system with aquaplanet (an idealised planet fully covered by oceans) states are expected.” The assumption of Flament et al. is not an aquaplanet sensu stricto, this study suggests that continents were mostly flooded until the end of the Archean, which means that the continental crust significantly affects the bathymetry.

(8) fig.9 and lines 2-5 p543. The authors must explain why the same pCO2 are not used for all runs ?

(9) fig.18. Continents are supposed to have a positive topography. Please correct this point.

(10) Here is a reference to add to complete the list

- Precambrian climate – the effects of land area and Earth's rotation rate. Jenkins, GS., Marshall, HG., Kuhn, WR. JGR-atmosphere, volume: 98, issue: D5, pages: 8785-8791, 1993 DOI: 10.1029/93JD00033

Interactive comment on Clim. Past Discuss., 9, 525, 2013.