

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

Anonymous Referee #3

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The authors investigate the role of albedo and of heat transport in the context of the Early Archean.

First, the manuscript is very poorly organised and major revisions are required before being published, both in terms of treatment and organization of the text. The paper consists in a set of sensitivity experiments to various parameters, which can be either related to the state of the Earth during the Early Archean or related to model parameterisations. In addition, results already published in Kienert et al. (2012) are mixed with new results. Finally results are shown and discussed in each section. A final discussion is needed. It will help the readers to better understand the role of each factor.

In conclusion, I strongly recommend a complete rewriting of this paper before publication.

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Major points:

P527-528: Introduction

A clear review of the state of the art must be done in the introduction.

P527-L13: I do not consider the model CLIMBER as a true 3-D model. The model Climber 3 α consists of a 2.5-dimensional statistical–dynamical atmosphere module coupled with a general circulation model for the ocean component (MOM3) (Eby et al., 2012). Thus, I do not believe that the AGCM used by Jenkins' work is a “highly simplified 3-D models”.

P528-L10: the area of emerged continental crust is due to both crustal growth and a change in hypsometry.

P529-530: The authors should add a sentence to explain how the values of model parameters were fixed.

P530-L13: The model includes an isothermal stratosphere. This is very surprising because the atmosphere is free of oxygen during the Early Archean. Thus there is no ozone layer.

P533: longwave parameterisation

The authors have fixed a parameter “a” which fits well with the results obtained with the MTCKD parameterisation (section 2.2.2 and fig.3). On fig.3, two other parameterisations are shown (CA and GBKM) which have never been cited either in the main text or in the figure caption.

A set of experiments has been done (section 4.2-P550) to test its impact on CO₂-induced greenhouse warming. The explanations seem to confirm what is already known about the importance of the parameter “a”. The section 4.2 should be transferred into section 2.2.2 or section 2.3.

P533 : atmospheric meridional cell strength

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The authors adjust the C_i factors using the temperature and velocities fields from aqua-planet simulations (Marshall et al., 2007). Marshall et al. (2007) have fixed present day values for CO_2 (and orbital parameters). The change in topography influences drastically the C_i factors. How do changes in $p\text{CO}_2$ or rotation rate act on C_i parameters?

P534-L23: equation (2)

The parameters of the equation (2) must be explicitly described. The authors should explain how the parameter R (or Ω) is influenced by a change in $p\text{CO}_2$? ΔT is the fractional change in potential temperature from equator to pole (Held and Hou, 1980), which varies in function of several parameters (not only rotation rate).

P536: overall impact of technical modifications

The additional experiments that have been done can be explained in this section.

P537 and p550: Figure 7 shows the surface and planetary albedo. The authors must explain why surface albedo exceeds planetary albedo at high latitudes (in case of sea ice). This remark is also true for the section 5.

P539: Two sensitivity experiments are performed to decipher the role of rotation rate and topography. These results are not discussed further.

P541: planetary albedo and clouds

The figure 7 must be simplified. It is not useful to show the results for clouds from all CMIP5 models (only refer to the work by Taylor et al., 2012). I suggest to make comparisons between runs (present day and preindustrial) and the observations in the section 2.3 because this only concerns the ability of the model to simulate present day climate.

P545: atmospheric dynamics

Figure 12 represents the mean zonal winds as a function of latitude, not height.

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P546: ocean dynamics

This section is interesting but must be more detailed. The surface velocities for 3 CO_2 levels must be shown. How do the ocean dynamics respond to sea ice (and reciprocally) ?

The authors compare Early Archean and preindustrial runs but these comparisons do not permit to analyse the respective effects of $p\text{CO}_2$ and rotation rate on ocean dynamics.

This comment is also valuable for heat transport.

P548 : impact of uncertainties in topography and radiative transfer.

This section must be shortened and discussed earlier in the paper.

The impact of topography should be shown before the effect of $p\text{CO}_2$ and rotation rate rather than the opposite. Concerning LWR parameterisation, the authors should discuss this point in section 2.2.2.

Minor points:

P528-L27: add a reference

P531-532: the section about topography can be shortened.

P537: It seems that orbital parameters have not effect on the symmetry (or asymmetry) of temperature (fig.5). Is it correct or is it due to the scale of the figure 5?

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