Clim. Past Discuss.,
https://doi.org/10.5194/cp-2017-159-RC3, 2018
© Author(s) 2018. This work is distributed under
the Creative Commons Attribution 4.0 License.

Climate of the Past Discussions

Interactive comment on "Coupled climate-carbon cycle simulation of the Last Glacial Maximum atmospheric CO_2 decrease using a large ensemble of modern plausible parameter sets" *by* Krista M. S. Kemppinen et al.

Anonymous Referee #3

Received and published: 16 February 2018

This article presents an ensemble of Last Glacial Maximum (LGM) simulations using the GENIE intermediate complexity model with varying parameter values. The model simulates the carbon cycle allowing the authors to compare the CO2 values obtained from the model with the 90 ppm decrease from ice core data and analyses carbon stocks, in addition to the study of climate variables. They select two subsets of simulations with increasing constraints and analyses the changes obtained in these simulations in terms of temperature, precipitation, sea ice, ocean circulation and carbon stocks with respect to the pre-industrial. The CO2 drawdown in most simulations is

due to an increase of carbon storage on land and in the lithosphere while the ocean gets depleted in carbon.

Using an ensemble of simulations to study the change of climate and of the carbon cycle during the LGM is a great idea and GENIE is an adequate model as it is fast enough for the long simulations required. However, concerning the carbon cycle part, the lack of carbon isotopes in the simulations prevents any real conclusion to be drawn on the plausibility of the results obtained and the likelihood of the associated mechanisms and carbon stocks changes. As the carbon isotopes are already incorporated within GENIE, providing that this is feasible, I suggest to rerun the simulations and redo the analyses with the isotopes (at least carbon 13) in comparison to data, which is crucial to properly evaluate the results.

General comments

1. As I said before, the main point is the absence of carbon isotopes which precludes any strong conclusion to be drawn, it would be best to redo the simulations with the carbon isotopes (at least C13, if possible C14) and compare with ocean and atmosphere data to evaluate which simulations are really plausible. How long would this take?

2. From the simulations done so far, we can't know which processes are responsible for the carbon changes, it would be great to have a few additional sensitivity tests (for example taking one set of parameters from the PGACF ensemble) to evaluate the impact of each process on CO2.

3. In the figures with maps, it would be good to draw the coastlines of continents to make it easier to see where the changes take place.

4. Âń conversely Âż appears 28 times in the manuscript, it could probably be removed or replaced a few times.

5. On the bar charts, all ensembles (grey, yellow and orange) could be drawn on the same plot to avoid having two subplots, which would help the comparison between the

ensembles and reduce the space taken by figures.

6. The hypothesis that carbon stays below the ice sheets is a strong one, it could be interesting to evaluate its impact by doing one (or a few) simulations from the PGACF ensemble without carbon kept under ice sheets.

Specific comments

p.1-2: The abstract is quite long, and could be better organized, with the problematic explained at the beginning before stating what is the main scientific question raised in this article, how it is raised, and then the main results.

p. 2-3: Permafrost is not mentioned in the introduction; it would be good to include it. It would also be interesting to introduce here which data will be later used to constrain the results.

p. 6: During the second stage of the simulations, how does CO2 evolve, does it stay stable?

p. 7 l. 12: In the EFPC ensemble, are the simulations at equilibrium at the end of stage 3?

p.7 l.21: The SST value is too high compared to data, how does that compare to other models? Is it in the range?

p.7 l.22 The sea ice value is given for the Northern and Southern Hemispheres, how is the comparison with data when split between the North and the South?

p. 7: The vegetation and soil carbon values are given in table 2 but are not discussed. How does it compare to data ? Is the vegetation distribution ok? Given that it plays an important role in the change of CO2 for the LGM it would be good to know if the preindustrial terrestrial biosphere is well represented or if it has important biases. There is also no discussion of the overturning values given, how does it compare to other models?

p. 9 l. 28-29 I'm not sure I understand or agree with this sentence as the simulations are for the LGM and not the other glacial maxima in terms of orbital parameters.

p. 10 figure 1: maybe replace PRE by PI and explain it somewhere: Pre-industrial (PI).

p. 11 l.10 and following: Could you use temperature and salinity data to select ensemble members that are supported by data?

p. 15 line 10: how does sea ice distribution compare with data?

p. 20 l. 3 Is it really "than in the PGACF-16"? Is this not the ensemble that you are talking about?

p. 20 line 10: NADW instead of AABW?

Figure 9: It looks like the NADW is stronger for the LGM than the Pre-industrial , while from the text and figure 8 I understood the opposite. . .

Figure 10: could you add the PGACF-16 ensemble?

p. 23 and following: could you show a map of where the carbon is stored on land ?

p. 37: the conclusion is long and more descriptive than conclusive, it might be good to re-organize it.

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2017-159, 2018.