

## ***Interactive comment on “Climate and carbon-cycle variability over the last millennium” by J. H. Jungclaus et al.***

**Anonymous Referee #2**

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Title: "Climate and carbon-cycle variability over the last millennium"

Authors: Jungclaus et al.

Summary:

The authors present a set of last millennium simulations performed with a complex AOGCM coupled with a carbon cycle component. The focus of the study is on the carbon cycle variability with respect to temperature changes due to different forcings. In comparison to ice-core data the CO<sub>2</sub> variability is still underestimated during the last millennium.

General comments:

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General the manuscript is well written and clearly structured. The paper is scientifically very relevant and should be published. However, there are still some shortcomings (see major comments). Therefore I recommend that the manuscript should be accepted after minor to major revisions.

Major comments:

I. page 1019 line 5-23: The whole paragraph should be also discussed in the light of the climate sensitivity of the model. There are several shortcomings: e.g., it is not clear which 30 yr period the authors use - is it just the warmest and coldest period in each ensemble member or is it the ensemble mean (which I would prefer as it fits better to the choice of Frank et al.)? How strongly does the timing of the periods vary compared to reconstructions? Do the authors use different period for different target variables like NH land or NH land summer, ...? Please insert the pdf of Frank et al in Fig. 3. The conclusion seems to be to strong - given the fact that the solar community heavily discuss the amplitude could be stronger, so how will the authors interpret their result if this is the case. Moreover, with the analysis presented they have not shown that differences among reconstructions are explained as a result of different spatio-temporal sampling among the records.

II. The second major concern relates to the fact that the authors argue that the E1 simulations are well within the range of NH temperature reconstructions and E2 is off compared to the reconstructions but the results of the carbon cycle (page 1023) are mainly presented for the E2 ensemble - this is a inconsistency which need an explanation.

III. Concerning the carbon cycle sensitivity the authors could also compare directly the Fig. 3 of Frank et al. 2010 by splitting their period into 1050 -1549 and 1550 -1800.

IV. There is no discussion of the results in Section 4, also the conclusions could be presented in a more comprehensive way.

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V. The selection of time filtering in the figures is not clearly explained, to give you an overview: Fig. 1: 11-yr running mean; Fig. 2 & 5: 31-yr running mean; Fig 6.: unfiltered ?; Fig. 7: low-pass 50 years and 31-yr running mean

Specific comments:

1. page 1012, line 18: There are a lot of publications of fully coupled AO-GCM & carbon cycle focusing on the last 150 yrs and the future - maybe it would be nice to mention some recent studies, e.g. Froelicher and Joos 2010 (Clim Dyn). Moreover, studies on the dynamics of the past 500-1000 yrs are also performed by several other groups: Stendel et al. (2006, Clim Dyn), Tett et al (2007, Clim Dyn), and Spanghehl et al. 2010 (JGR)
2. page 1012, line 22/23: I suggests to remove 'Readers who ... and 2.2.'" as this is not necessary. Some readers will do this anyway.
3. page 1012, line 23/24: "... starting with a comparison of simulated and reconstructed NH temperatures, followed ..." reads better.
4. page 1015, line 20/21: The reference is misleading. Timmreck et al use the same model to understand the 1258 AD eruption so at least the authors should mention here some reconstructions they use to proof that the response to 1258 is in agreement.
5. page 1017, line 17: "The simulated global CO2 increase ... shows a somewhat less ..." is clearer.
6. page 1017, line 17/18: Why do you find a less upward trend? At least present a hypothesis.
7. page 1018, line 25/27: Is this 'difference in spread' statistical significant - I have my doubts when looking at Fig. 2b. Please test and in the case it is not significant please remove the statement.
8. page 1018, line 28: Give a reference for statement, that 1600-1650 is the coldest

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period.

9. page 1019, line 2: 'swing' implies a clear (periodic) process and yet there is no commonly accepted one for the MWP-LIA transition, so I suggests to you instead 'variability'.
10. page 1019, line 16: The sentence 'Therefore it seems ...' is awkward and has to be clarified.
11. page 1021, line 27: Maybe 'highlighting' reads better than 'signaling'.
12. page 1022, line 15: As I do not have the possibility to read the Brovkin paper (as it is in review) I wonder that the long-lasting imprint is the trend of the light-blue line in Fig 5b, correct - if so it would be nice to add a sentence of two, explaining why you found such a imprint.
13. page 1023, Line 1: here I am puzzled - how have you estimated gamma for the unforced simulations, do you really mean the CTRL simulation?
14. page 1023, line 3/4: This is an interesting analysis however I miss an interpretation or a hint of an underlying process which is responsible for this time dependence.
15. page 1026, line 17: A segment length of 1 yr seems to be awkward. I guessed that the authors use yearly data, so 1 yr segments lead only to points and thus it is impossible to estimate a linear trend. I think the method has to be clarified.
16. page 1027, line 23-25: The sentence needs clarification, maybe splitting it into two will help.
17. page 1035, Fig1a: The simulation with a weak solar forcing (E1) show during the 20th century a higher response in NH temperature than the simulation with high solar forcing (E2, dashed lines). Knowing that the solar forcing is increased during this period and shows a linear trend this behavior is counterintuitive.
18. page 1036, Fig3c: Please do not smooth the volcanic forcing as it might lead to a

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miss interpretation, e.g., a 'permanent' volcanic eruption from 1800-1830. I also cannot believe that it is a running mean - I would expect that at the beginning and the end of the simulation 15 yrs are missing.

19. page 1038: An information which periods are shown might be useful, maybe in a table.

20. Page 1040, Fig5b: Why do we see such a strong negative trend in the light blue experiment?

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