Geoscientific
Model Development

Discussions

Interactive comment on "The Climate Generator: Stochastic climate representation for glacial cycle integration" *by* Mohammad Hizbul Bahar Arif et al.

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This manuscript present the development of a novel tool to efficiently model climate change during long time period such as glacial interglacial cycle. This is a statistical tool which "generates" climate based on temperature simulated by an efficient climate model (here an Energy Balance model; EBM) and other parameters (geographical coordinates, elevation, greenhouse gases, orbit. . .). This "climate generator" is trained on long simulations run with two general circulation models, FAMOUS and CCSM3. This work is very novel and interesting and this manuscript is a perfect fit for the GMD journal. I would recommend this manuscript for publication within GMD, but with some more discussion and improvement of how the methods and results are presented. I think broadly the work is robust and sound and the analysis is complete.

Main comments:

One important aspect of this tool is that it requires input of temperature from an EBM as well as being trained on output from a GCM. I think this needs to be further explained. In a sense, this tool provides bias-correction to the EBM as well as incorporating climate variability (in time and space) that is learned from the GCM and providing compatible precipitation. I would be interested to know why EBM temperature input is required, would it be possible to train a tool that just requires coordinate, time (or GHG, orbit) and elevation input. More broadly, I think clarifying the assumptions and aims of this climate generator might help describe the methodological choices made and the criteria for validation.

The introduction section on page 3 reads like a long list of methods that could have been used for this study. I found it a little bit hard to follow (lots of new concepts for me). Can you clarify why specific method aren't used here, highlight a bit more which one is used and why ? I think all the information is there, but a few tweaks would help the reader assimilate the ideas.

The text needs a bit of reworking. I would suggest section 2.1 be merged with section 3 and 4 as it all describes "Methods". Section 2.1 by attempting to be just a part of the introduction ends up being too vague in places, particularly for 2.1.4 Climate turning test. Section 4.2 on the BANN implementation is a bit hard to follow for a non-novice, I think this section requires a bit more narrative and explanation of the process.

The results section is also hard to follow because the tables and figures are not systematically referenced in the text. I'm not even sure that all the figures are referenced in the text.

The discussion section seems to end a bit abruptly with the introduction of the concept of "reality". In this study, "reality" is whatever the climate generator is trained on. This is kind of explained in section 2.1.3, but not so clearly. I would suggest clarifying to justify the comparison made between CGfamous and FAMOUS and expanding the

discussion section on this topic.

On a related note, there is a lot of comparison of CGccsm with FAMOUS, but is that comparison fair ? If the climate generator is trained on data from CCSM, its effectiveness should be tested against CCSM (the new "reality"). I note in particular that CGccsm is consistently better at matching CCSM than CGfamous is a matching FAMOUS. Could you comment on this point and suggest a reason for this ?

5 consecutive years of FAMOUS isn't quite a 50 year climatology despite the acceleration. The interannual climate variability is not accelerated in the model, therefore an average of 5 years will not give a climatology equivalent to a mean of 50 years. This has important implications for the definition of climate "noise"/variability in this study and for the behaviour of the simulator. Please include a discussion of this in the manuscript, with specific reference to what timescale of climate variability the stochastic noise added is meant to represent.

The testing/validation of the climate generator is done only for two months of the year, February and August. Why not do the RMSE and Taylor diagrams on all months of the year aggregated into one metric ?

More detailed comments:

Page 5 line 5 and line 19. I think those two sentences say the same thing.

Page 5 line 6. Please develop a bit more why these EOF in theory could help capture non-local effects and what you mean by that. I think I can guess, but it is not that obvious.

Section 2.1.4. quantify what is meant by "relatively high correlation,[. . .] close patterns and reasonable capacity. . ."

Section 3. I think there is some confusion between training period and test period. CCSM3 is only available over the training interval (deglaciation).

Page 6 Line 19. Justify choice of lapse rate and implication

Page 6 line 29 "unreasolved variability" by what, the EBM ?

Page 9 line 26 the last sentence in this paragraph is a bit confusing, what you are doing is comparing the results of BANN with a different set of inputs and architectures.

Table 1. What is the difference between "CO2+ CH4" and "carbon dioxide, methane" in PS2 and PS3 ? are you using the sum of greenhouse gases in PS2 are are they two individual inputs ?

Table 3 and onwards, can you clarify that the MD and RMSE is aggregated not only over space, but also over time.

Page 14 line 2, "Table (4)" -> Table 4

Page 15 line 8, please justify why you take the difference between CCSM and FAMOUs as the minimum value of model uncertainty.

Page 15 line 11 (and elsewhere throughout the results), refer to appropriate table.

Page 16 line 4 "test part" -> test period ?

Page 16 line 11 TABLE -> Table

Figure 5, you have two blue line that are hard to distinguish

Figure 6. Can you comment on the fact that over the ice region, the prediction of spatial mean august temperature over the north American ice sheet by CGfamous are radically different (and appear to the anticorrelated) to both FAMOUS and the EBM tempreatures.

Figure 7,8 the use of column is confusing in a landscape figure, I would just make more use of labels and state dates in the captions

Page 25 line 8 CGcssm -> CGccsm

Page 25 line 13. What do you mean by "retained" ?

Page 25 Line 15: "more advanced" than what ?

Repetition within some of the figures in the supplementary material. For example between figure 6 and 7. The supplementary figures do not all follow the same template, which makes them confusing to read.