



## ***Interactive comment on “Development of a system emulating the global carbon cycle in Earth system models” by K. Tachiiri et al.***

### **Anonymous Referee #1**

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### General Comments

This paper presented a new EMIC (Earth System Models of Intermediate Complexity) based on a modified AOGCM (MIROC-AOGCM) and a terrestrial biosphere model (Sim-CYCLE) to effectively simulate the coupled cycles of climate and carbon at global scale. To compensate the poor calculation of fast but simplified climate model (energy-balance type model), the authors attempted to replace EMIC-based climate with full-GCM based one. The way is to use GCM-based climate by referring corresponding CO<sub>2</sub> concentration (CO<sub>2</sub> is calculated by the EMIC). The idea is very interesting and worth of publication. I am sure that the proposed model can be a powerful tool for ESM and EMIC society because it is very fast to execute the model and more experiments can be achievable. The strongest point is this EMIC can assess the effect of different

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AOGCM on global carbon cycle and climate by switching to different GCM outputs. This study is very innovative.

However, in my opinion, the manuscript is not ready for submission. In fact, it was hard for me to understand all contents. One of the reasons is poor presentations and insufficient description (too many Figures are presented, and some can be deleted) of Figures. In addition, the manuscript is in a very weak form and needs substantial revision by checking each sentence and whole organization. I am afraid that I cannot make appropriate comments due to insufficient understandings. Therefore, my conclusion is substantial revisions are required before publication.

### Major Comments

1. The authors should improve figure quality throughout the manuscript. Especially, for graphs, I am sure most are created by EXCEL, and these need substantial improvements. All graphs should be more consistent in terms of presentation (e.g. Font, grid-line etc.). Figure 1, the each rectangle and arrow should be more organized. Maybe, a box of 'atmospheric carbon budget calculation' is not required. 'CO2 level calculation' should be 'atmospheric CO2 level calculation'. Figure 2, no need. Figure 3, labels of longitude should be 0E, 90E, 180E, 90W, 0W or similar. Figure 3(d), saturated color (most region, simply red). Need change the range. Figure 4, Unit of numbers. Modeled topography should be also presented. Figure 5, I could not understand its role. What is 1.61? Figure 6, probably no need. Figure 7, add label of 2nd y axis. Figure 9, should be more consistent (e.g. size) among two figures. Frame of the figure should be removed. Figure 10, frame of figure deleted. X-axis should be more organized. Figure 11-15, frame should be deleted. Figure 16-17, Figures are very confusing, and I could not understand their roles.

2. Results should be more concisely presented. In some figures, no interpretation was given. Even for others, interpretation of the results was given too briefly. Results should be discussed more in detail.

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3. Definitions of ESM (Earth System Model) and EMIC (Earth System Model of Intermediate Complexity) are confusing. ESMs contain various components of the earth such as atmosphere, land, ocean, ice, carbon cycle, climate and so on. I thought EMICs is a reduced form of ESMs. The authors called reduced form of MIROC (MIROC-lite, which integrated atmosphere and ocean basically) as EMICs. In my impression, the whole integrated system (LCM) should be called as EMIC.

Minor Comments.

1. Introduction. P64L13. Pulse-response function is another approach to mimic GCM climate (Joos et al., 2001). Need to mention the work.

2. Method. P65L19-22 (section 2.1). Need more description on overview of LCM.

3. Method. P67L6 (section 2.2). What is original model, Oka et al. (2001) or Oka et al. (2010)? Need clarification.

4. Method. P67L13-17 (section 2.2). This paragraph should be moved to the result section. Figures 3 & 4 are basically results from LCM as far as I know.

5. Method P67L23 (section 2.2). What is 'the original model'? Need clarification.

6. Method P67L25 (section 2.2). SAT is firstly used here. Need to explain.

7. Method P67L28 (section 2.2). I could not find the role of Figure 5. Need more explanation if the authors need to show here. Or maybe remove it.

8. Method P69L7-8 (section 2.3). This paragraph describe overview of MIROC3.2 and Sim-CYCLE. Therefore, move to section 2.1.

9. Method P69L17. Figure 6 is not well explained in the manuscript. Add more description for evaluation or delete it. By the way, Is figure 6 the result of offline spinup or coupled model spinup?

10. Method P69L18-19 (section 2.3). I don't understand the role of this paragraph.

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Delete it.

11. Method P70L2 (section 2.4). 'a sensitivity of 4.0K' Need more clarification. 2xCO2 sensitivity?

12. Method P70L19. (section 2.4). Fig. 7 is not necessarily explained here. Move to the result section.

13. Method P70L23. (section 2.5). By referring CO2 concentration, corresponding year is selected. Then, how did you get daily climate? Need clarification.

14. Testing and tuning the LCM. P71L27. What is 'ensemble integrations'? Need clarification on experiment.

15. Testing and tuning the LCM. P72L9. Please explain pCO2a and pCO2o, and describe units of all variables in equation (5).

16. Testing and tuning the LCM. P72L11. How to estimate SI from T and S. Reference is required.

17. Testing and tuning the LCM. P72L14-16. Need more explanation on results.

18. Testing and tuning the LCM. P72L28-P73L5. Add more explanation on interpretation of the results. Currently, I don't understand what the authors would like to express from these Figures.

19. Testing and tuning the LCM. P73L27-29. Need more interpretation of the results.

20. Testing and tuning the LCM. P74L1-8. Figs 10-13 were repeatedly explained in this paragraph. It will be helpful to move them to P73L5.

21. Discussions. P75L12-29. I could not understand its contents. Please rewrite.

Reference: Joos, F., I. C. Prentice, S. Sitch, R. Meyer, G. Hooss, G.-K. Plattner, S. Gerber, K. Hasselmann, "Global warming feedbacks on terrestrial carbon uptake under the Intergovernmental Panel on Climate Change (IPCC) emission scenarios", Global

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