

Interactive comment on “An isopycnic ocean carbon cycle model” by K. M. Assmann et al.

Anonymous Referee #1

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This manuscript describes a newly developed isopycnal ocean carbon cycle model, which is a useful complement to the current ocean carbon cycle models that are mostly based on horizontal/vertical coordinates. The construction of this model must have been a tremendous modeling work. The construction and evaluation of the model is quite extensively discussed. This manuscript fits well the scope of Geoscientific Model Development, but I think significant improvement is needed before it can be published in GMD.

Major comments

Model evaluation: The newly developed isopycnic ocean carbon cycle was evaluated in terms of temperature, salinity, DIC, phosphate, oxygen, and uptake of anthropogenic CO₂. However, there is no discussion about how the model-simulations of radiocarbon (in terms of Delta 14C) and CFCs, two of the most important chemical tracers

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typically used to evaluate ocean models, are compared with observations. There is a long history in using the simulation of natural radiocarbon to evaluate modeled ocean mixing and circulation over the timescale of several thousands of years, and using the simulation of bomb radiocarbon and CFCs to evaluate modeled ocean ventilation over the timescale of several decades. The simulation of natural 14C, bomb 14C, and CFCs is an essential part of ocean model evaluation, which should be included and discussed (For example, the standard simulation protocols of radiocarbon and CFCs used to evaluate ocean carbon cycle models participating Ocean Carbon Cycle Model Intercomparison Project, OCMIP , <http://www.ipsl.jussieu.fr/OCMIP/>)

Sensitivity studies: It looks to me that all of the sensitivity studies should be conducted with the model spinup to allow the model to reach equilibrium. As shown in section 5, the focus of the sensitivity studies is on nutrient distribution, I see no particular reason to perform these sensitivity studies under anthropogenic CO₂ emissions and NCEP forcing and only for 60-years.

Specific comments: Abstract Page 1024 Lines 12-14 “The most significant adjustments of the biogeochemical code. . . . ocean biological production” Please rephrase this sentence. What is the biogeochemical code used here?

1 Introduction: Page 1025 Lines 5-8 “due to its relatively quick turnover time scale of 1000-2000 years . . .” In what context is the time scale of 1000-2000 years can be considered as “quick”? What is the comparison here? Please clarify. Also, if we consider the entire ocean, the turnover time is longer than 5000 years.

Page 1026, Line 2 Please clarify what you mean by “sinking oxygen water column levels”

Page 1026, Line 9 Please clarify what you mean by “reverse weathering”

Page 1027, Line 20 “induction” should be “introduction” ?

Page 1027, Line 23 Please clarify what “uncertainty assessment” refers to.

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2. Model description Page 1029 Please state what 'M' stands for in equation (1) Page 1030 Based on what the value of background diffusivity C is set ?

Page 1034, Lines 16-18 Please rewrite the sentence "For computational efficiency ran the biogeochemical . . . time step".

Page 1035, Line 13 "The model was spun up for 950 years" My modeling experience is that for dynamic ocean models, it usually needs more than several thousands of years of spinup for the entire ocean to reach equilibrium. It needs to be justified here why 950-year of simulation is sufficient for the model spinup. What are the criteria used here to determine whether the model equilibrium has reached?

3 Model results and evaluation Page 1039, line 4 "relative strong AABW cell of 14Sv", relative to what? Is there any observational evidence showing that 14Sv is 'relatively strong' for AABW cell?

Page 1039, line 7 "show a realistic North Atlantic overturning of 14Sv", please give evidence/references here to show that 14Sv is realistic for North Atlantic overturning.

Page 1040, lines 17-19 "According to the Taylor diagramme, oxygen, . . . Is the tracer that the model simulates best" As the authors stated, in addition to biological processes, oxygen distribution is affected by temperature. The fact that oxygen simulation is better than that of phosphate could be a result that the bias in simulated biology and simulated temperature offset each other, which should be discussed here.

Page 1041 lines 11 to 12 "POC export production at 12.4 . . ." The strength of POC export production could be very sensitive to the depth at which the export is defined. It should be clearly stated at which depth the modeled POC is defined here.

4. Air-sea fluxes and the uptake of anthropogenic CO₂ Page 1043, line 25 I understand that climate change tends to act as a positive feedback for atmospheric CO₂, but please state more clearly what is the "carbon cycle-climate feedback of less than 15ppm"

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5 Sensitivity studies

IRON: It is not clear to me how the IRON simulation differs from the default model simulation. It is stated in the model description section that "The model includes an ecosystem model . . . with nutrient co-limitations by phosphate, nitrate and iron (Aumont et al., 2003)" (Page 1032, Lines 21-23). Does the default model have no iron limitation? Also, please include a description of how the iron cycle is simulated in the model. The last paragraph of this section. I don't think that the discussion of changes in simulated export production and atmospheric CO₂ from these sensitivity experiments is useful. What do these results mean? Do changes in export production and/or atmospheric CO₂ suggest improved model simulations as a result of changes in model physics and/or nutrient limitation? Again, these sensitivity simulations should be performed under constant atmospheric CO₂ concentrations with model simulations reaching equilibrium.

6. Discussion Page 1048, line 12 "After a thorough evaluation we conclude . . ." The ocean carbon cycle has not been evaluated using the simulations of radiocarbon and CFCs, two of the most important chemical tracers used to evaluate ocean models. This makes it hard to convince me (and probably the readers) that it is a 'thorough evaluation'.

Page 1048, line 16 What is "layered ocean models"?

Page 1048 line 17 "our attempt has been more successful" Please clarify to what aspects the attempt here are more successful.

Page 1049, line 24 "modeled iron concentrations agree with available observations" Please include a figure showing this. Also, please add a description of how the iron cycle is simulated in the model.

Figures: Fig.2. Please give a short description of the Taylor diagram for readers who are not familiar with the construction and meaning of this diagram.

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