Review of gmd-2021-222: *Use of Genetic Algorithms for Ocean Model Parameter Optimisation*

By Marcus Falls, Raffaele Bernardello, Miguel Castrillo, Mario Acosta, Joan Llort, and Martí Galí

Minor Revision Recommended

In this paper the authors describe a novel technique for tuning the parameters of an ocean biogeochemistry model using a genetic algorithm. The algorithm borrows ideas from natural selection in order to simulate the evolution of a set of parameters towards a defined optimum, which crucially depends on the definition of a cost function. The authors build a framework using AutoSubmit for conducting such an optimisation with the PISCES biogeochemical model. They try the algorithm in a few different contexts, comparing not just against a reference simulation but also directly against observations, when calculating the cost function. They find that the algorithm is much more efficient than a brute force or random search approach, though there are caveats about certain model parameters and the nature of the optimisation.

I personally found the experiments fascinating, and I am glad to see more research about genetic algorithms in the Earth Sciences, as model parameter tuning has always struck me as an obvious candidate application. The paper is well structured and the language is high-quality. It is however rather dense and difficult to read at times, so I've recommended some suggestions below. None of these suggestions require further research or experiments so I have classes this as a minor revision. I look forward to the authors' resubmission.

Major comments

My main criticism regards the length and density of the paper. Excluding the appendix, there are 27 figures and tables conveying a very large amount of information between them. I personally found this aspect very difficult to follow, and by page 20 I was having to switch back and forth between 3 or 4 pages with every sentence in order to corroborate the authors' statements. I would suggest to the authors to reduce the amount of information in the paper, or delegate more of it to the appendix. As a rough guide, perhaps the number of figures and tables can be reduced to 17, though I leave that to the authors' discretions. Of course, if the authors insist on keeping this amount of figures, they are welcome to. But I believe that following such a rough target will encourage the authors to digest and summarise more of the information, thereby reducing also the word count and making the reader's experience easier.

I can certainly offer some suggestions:
- Section 3.1.3: The take-home message here is that RS does better than GA. This is good news but also expected. Is it necessary to have a section just to state this?
- Does Figure 12 say anything in addition to Figure 11? It's only briefly mentioned once in the text.

- I suggest to reconsider the other tables showing numeric values at the end of the optimisations — do they really provide any more insights than the corresponding figures showing the full evolution graphically? If necessary, you can certainly mention numeric values in the text, but I'm not sure showing all of them is necessary.

Minor comments

- Line 82: "[Genetic algorithms] have been applied to many global search problems and, in recent years, have also started to be used in numerical modelling to avoid the limitations of today's weather and climate models." - I believe this statement but I'm not personally familiar with any examples. Could the authors provide one or more citations?
- Line 107: typo: "profiles of ~~in~~ the North".
- Line 199: I don't think "partition" is the natural choice of word here, and it confused me at first. Usually you "partition" something into multiple groups, but here only one group, the elites, is mentioned. I would suggest "At each generation, the p_e individuals with the best score, known as the elites, are selected, where $p_e < p/2$".
- Line 200: Similarly, I would suggest "The remainder of the vectors are placed into the non-elite set".
- Line 201: "sets" is used twice, so now I'm confused. Is it really p_m *sets of sets* of vectors? Is it not "Next, a set of p_m randomly generated vectors are introduced…"?
- Line 204: Again, I am confused by the use of "vector sets". Is it not "A crossover in this case is a method used to generate a *new vector* by selecting two parents at random…"? The current wording implies that you re-use the same parents for all vectors produced in the crossover step, which I don't think is the case.
- Line 230: Should it be S_3?
- Line 318: The text refers to *wsbiomax* but the top right title in Figure 3 is *wsbio2max*. I suppose one of these is a typo.
- Figures 7 and 8: The caption mentions just D5 even though D5_rand data is also displayed.
- Line 354-355: It looks like RS is actually better than GA for "bPOC - RMSE" in Figure 9, which contradicts the statement here. The median error is lower for RS. What am I missing?
- Line 392: The optimised values for wsbio for the three experiment sets are 0.795, 0.179 and 0.008. I'm not sure why the first, O5_LAB1 is highlighted as being an outlier. All three of these numbers seem to be inconsistent with each other. Did the authors mean to highlight a different number? Perhaps they meant wchldm of O5_LAB1 which is an order of magnitude lower than the other two?
- Line 411: typo - ~~dependant~~dependent.
- Line 421: Do you mean *Figure* 10?
- I looked for supplementary figures S1 etc. but couldn't find them. I think the authors are referring to the appendix figures which have different labels. Please correct them.