

Geosci. Model Dev. Discuss., referee comment RC1  
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## manuscript review

Anonymous Referee #1

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Referee comment on "WAP-1D-VAR v1.0: Development and Evaluation of a One-Dimensional Variational Data Assimilation Model for the Marine Ecosystem Along the West Antarctic Peninsula" by Hyewon Heather Kim et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2020-375-RC1>, 2021

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The authors present a parameter estimation and sensitivity study, applying a variational optimization technique to a 1-dimensional ecosystem model for a station off the coast of Antarctica. The manuscript is concise (sometimes too much so) and presents a sophisticated optimization framework with an interesting application. It could be improved by showing if and to what extent the results generalize to different initial parameter values.

### general comments

The manuscript is generally well written but in places it overestimates the project-specific knowledge of the reader. Some implementation details are hinted at, but not described fully or until later in the manuscript. I have pointed out several of those instances in the specific comments, one example is the "removal" of parameters from the optimization which is a key aspect of this study but not described in much detail. According to the description, an optimized parameter with  $\sigma_f$  larger than 50% is updated but then removed from the optimization procedure, but according to Table 2 most of the parameters are never updated and somehow removed before the update. It is unclear how this happens.

It is nice to see a large Monte Carlo experiment with 1000 simulations to examine the model solution in the parameter space close to the optimized parameter values. However, I would argue that a more important aspect of an uncertainty analysis was left out of the manuscript. How sensitive are the results presented here to the initial choice of the parameters? If starting in another place in parameter space, does the algorithm end up in a different local minimum? Is the same subset of 14 parameters selected consistently? Do the results of the Hessian matrix analysis differ significantly in a different local minimum? Is an 80% reduction in the model-observation misfit typical? These are questions that may be more important to a modeler who would like to perform a similar parameter estimation experiment. I would suggest that the authors perform a second (but perhaps smaller) Monte Carlo experiment and assess the sensitivity of their results to the initial parameter values. This would not need to include every aspect of their original analysis and the results for their "reference" experiment could stay and be augmented with the

new results.

When comparing the results of the optimized model with the initial one (Fig. 5 vs Fig B3), the most striking difference to me was the presence of much higher frequency variation in the optimized solution. What is causing this variation and is it realistic? If so, were the initial parameters based on particularly bad guesses, since they do not show the variation? Where possible, it would be useful to overlay these plots with the data used in the optimization procedure. Also, I think lots of readers may be interested in the before-and-after optimization comparison and I would suggest to add Fig. B3 into the manuscript body for comparison, and perhaps even show corresponding panels side-by-side.

Along the same lines, why is a comparison to the initial solution avoided in so many places, for example why not include its results in the Taylor diagram in Figure 4? But maybe I am misinterpreting the initial solution a little: A reader may assume that the initial parameter values were the best values one could come up with, without going into a rigorous parameter optimization exercise such as the one presented in this manuscript. But here it appears more like the initial parameter values are based on a first (informed) guess without yet checking the effect of the parameter values on the model state. Is there any indication how "good" the initial values are, are the initial state estimates somewhat reasonable?

### **specific comments**

l 18: "Here we developed a one-dimensional, data assimilation planktonic ecosystem model [...] the pre-existing food-web and biogeochemical components of the WAP-1D-VAR model": It is not clear here if the model was developed from scratch, as the first sentence states, or that parts of the model existed before and were used here.

l 24: What are "intercompartmental flows"? Later in the abstract, "model state variables" is used and it would be good to use one expression consistently.

l 27: "... and comparable values of the assimilated and non-assimilated model state variables and flows to other studies": This is a run-on sentence and difficult to understand, I would suggest to break it up and rephrase the second part.

l 188: At this point it is not clear what the water depth at the model site is, how deep the model extends and how it reacts to a growing (deepening) ice cover or if this is even a concern at the site. If the authors want to keep this implementation aspect general, it would be good to make this explicit and mention under which circumstances the modeling framework can be used.

l 232: "using the new set of modified parameters": After reading a bit ahead, it is unclear if these modified parameters refer to modified parameter values or new parameters, as some have been removed from the optimization. In general, I would suggest to use the term "parameter value" instead of "parameter" whenever the text refers to the values rather than the parameter itself.

l 240: The removal should be mentioned and explained in the description above.

l 262: "for growth seasons' relatively complete data coverage for modelling purposes": I am not sure what this means, please rephrase. Listing the years without any further information is not very helpful to the reader, does it imply that a new CV is estimated for every one of those time periods?

l 289: "optimized model simulation": Does this imply parameter estimation?

I 291: It would be beneficial to the reader to rephrase "2002-2003, 2003-2004, 2004-2005, 2005-2006, 2006-2007, 2008-2009, 2009-2010, 2010-2011, and 2011-2012 period" to something like "9 growth periods between 2002 and 2012 (the 2007-2008 growth period is missing because of X)"

I 293: "averaging across all these 9 years did not reflect distinct seasonal phytoplankton peaks": What is meant by "reflect" here? Am I understanding this correctly, that phytoplankton blooms occurred at different times in the years that were examined, and so the "simple" climatology did not show any bloom? Then a more complex climatology was constructed using the time shifts to align all blooms. Was the model then optimized using parameter estimation? Were the optimized parameters used to inform boundary conditions or was the climatology used for that? More information would be useful here.

I 308: "but given cryptophytes being the second dominant species in the water samples they are considered to represent non-diatom species": I assume I know what is meant here but it would be good to clarify this point a bit more: The dataset contains data for diatoms and "non-diatoms", and here in this modeling study cryptophytes are assumed to represent all non-diatoms?

I 310: "POC(N)": I presume this is meant to mean "POC and PON" and not "POC and N" in this context. Here the "()" are used a little differently than they would normally be used and I fear it could be confusing to some readers. I would suggest to use "POC (PON)" or make the sentences a bit longer use "POC and PON" and avoid the "()".

I 349: "Some of these model biases cases were evidently shown on a point-to-point basis": It is not clear what this means, please rephrase.

I 353: "The data types with relatively high correlation coefficients tended to have relatively low centred RMSD and vice versa.": In Figure 4 it looks like "BP" with a "relatively high" correlation coefficient (according to the definition from the preceding sentence) has maybe the highest centered RMSD value.

I 354: "the model fitted average observations slightly better": It would be nice to add different colors for those in Figure 4. Otherwise, the reader may have to go back to a few sections to review which observations were averaged.

I 359: "Among the total of 72 optimizable model parameters, subsets of 14 [...] parameters changed": It is still not entirely clear to me how this is done in the algorithm, are the remaining parameters dropped from the optimization before the first iteration? Also, "subsets" appears to imply multiple experiments with different results, yet Table 2 only shows one subset, i.e. 14 parameters with a value for  $p_f$ .

I 369: "The optimized model results at each model time step and grid were associated with generally small errors derived from the Monte Carlo experiments (Figure B2).": This sentence is difficult to understand, is it mean to say that the ensemble of state estimates obtained from the Monte Carlo experiment, that was conducted following the optimization, has a low standard deviation? As an aside, I would suggest not to mix the terms error and uncertainty here: shown is the uncertainty in the state estimate not an error that needs to be corrected.

Figure 1: In the figure description: "oragnic"