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Interactive comment on "Potential predictability of marine ecosystem drivers" *by* Thomas L. Frölicher et al.

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Journal: Biogeosciences (BG) Title: Potential predictability of marine ecosystem drivers Author(s): Thomas L. Frölicher, Luca Ramseyer, Christoph C. Raible, Keith B. Rodgers, and John Dunne MS No.: bg-2019-506 MS Type: Research article

This manuscript is a well written, interesting analysis of limits to prediction of biogeochemical quantities in a global Earth system model. I particularly liked the oceanographic explanations for the outcomes of the numerical experiments, and deconvolution of drivers. I am not an expert in global model predictability, but I suspect it is important for the field to undertake a number of these experiments on different models (the authors say this themselves). Even if similar studies exist, or follow this one,

this study will remain important. Therefore, I recommend publication with the following, relatively easily-addressed points considered:

Major comments:

1. As someone not familiar with this form of model sensitivity analysis, I found some jargon that could have been avoided, or better explained. The term 'perfect modelling framework' was introduced as though the reader should know what it means. More simply the study is a test of the sensitivity of biogeochemical quantities to temperature initial conditions.

2. By using temperature the emphasis is on limits to prediction of physical driving of biogeochemical quantities. Other initial conditions could have equally been perturbed, such as salinity, nutrients etc. And of course there are many other factors limiting predictability, such as the model parameterisation. This isolation of one source of limits to prediction is appropriate but should be made clearer in the introduction, and then discussed, in the light of the results, more thoroughly in the Discussion. For example, changing BGC models, or even the remineralisation rate of organic matter, would change the time scale of AOU.

3. [Most important point that needs addressing]. The terms "lead time" and "predictability time horizon" are used interchangeably in the last paragraph of p8, which demonstrates an inconsistency. The term lead time makes sense to me in Fig 2, 4 and 5. It is the time axis, starting at the perturbed time, along which the variability of the ensemble and controls are measured. But figures 3, 6, 7 etc. the surface plotted is labelled "lead time" when it should be "predictability time horizon". Predictability time horizon is loosely describes as PPP < 0.183 (also, is prognostic potential predictability the same thing as predictability time horizon)? But this is problematic since PPP varies with time. Should it be min t for which PPP(t) < 0.183? Check every use of lead time, PPP and predictability time horizon and make sure it is consistent in the manuscript. Predictability is also loosely defined, and would in many cases be best replaced with

“predictability time horizon”.

4. Fig. 1b. This figure would be more instructive if it was used as an example of the calculation of the PPP. If the control variance could be plotted (maybe a grey between +/- sigma) and then PPP, and the point at which PPP drops below 0.183. This would set up the rest of the manuscript better. Also, in the caption, why do you call it the “first ensemble simulation”.

5. Paragraph 396 – 405 needs re-writing for clarity. I think it is trying to say that you can have different time scales for predictability for perturbations in forcing (such as anthropogenic CO2) to perturbations in initial conditions (as studied here).

6. The discussion has too much focus on obvious limitations (such as ensemble size, years started etc.) and less on more subtle limitations like time-scale of coefficients in the BGC model. The second are particularly worth of discussion here because the effort at deconvolution of the processes allows for an insightful discussion of these.

Minor comments.

1. Whenever referring to time values, try to keep the adjectives to ones with a sense of time such as low -> short (L254), elevated -> lengthened (L195), high - > long (L391). This aids readability. There are many examples of this.

2. The sentence L91 starting “The six “should come before the “Note” for better readability.

3. L92 replace “are” with “were”?

4. Line 100. For those interpreting the equation, maybe a sentence after it “Thus the range of perturbations is evenly spread from -0.002 to 0.002 C with the control in the centre.”

5. L110 replace “underrepresented” with “underestimated”

6. Description of Eq.2 (L119-120) doesn’t mention the six ensembles. I didn’t fully

understand the rationale for 6 ensembles of size 40. Why not 240 members starting at all different times? Also is sigma of the control the same for all ensembles? Just a little bit more help here to those unfamiliar with the approach.

7. L150 pH is approximately –log10([H+]). I know you didn’t mean to define it here, but the use of (or X) sort of implies it.

8. L184 meaning of “PPP with lead time” not clear.

9. L206 replace “across” with “for each of the”

10. L234. How can a coupling enhance predictability? Sentence needs to be more carefully constructed.

11. L387 “predictability of each variable”.

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