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Comment on esd-2021-104

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Community comment on "Carbon Dioxide Removal via Macroalgae Open-ocean Mariculture and Sinking: An Earth System Modeling Study" by Jiajun Wu et al., Earth Syst. Dynam. Discuss., <https://doi.org/10.5194/esd-2021-104-CC1>, 2022

This seems like a nice paper addressing an important topic. Thank you, authors !!

It would improve the paper to perform additional simulations with atmospheric CO₂ concentrations specified to be the same as the Control_RCP4.5 simulation or held at pre-industrial concentrations.

If we were doing a study on the efficacy of geologic storage in a leaky reservoir, we would not need to model the terrestrial biosphere to see the terrestrial biosphere response to the leaked carbon. It would be enough to assess the geologic storage by knowing the leak rate.

For example, let's see I remove a ton of CO₂ from the atmosphere using kelp. If we allow atmospheric CO₂ to respond, there will be outgassing of CO₂ out of the rest of the ocean. This same thing would happen if we used direct air capture on land, but we would not say that the efficacy of direct air capture on land is diminished by ocean outgassing. We would say that the ocean responds to an atmospheric CO₂ removal opposite in sign as it would respond to an atmospheric addition.

Another way of thinking about a constant (or specified) atmospheric CO₂ removal is it is answering the question: how much more (or less) CO₂ could be emitted to the atmosphere to maintain the same concentrations. With direct air capture, we say one ton is removed because we could emit an additional ton with no net effect on the atmosphere.

This issue is discussed in Chapter 6 of the IPCC SRCCS (<https://archive.ipcc.ch/report/srccs/>) Box 6.3 on page 293. "Fraction retained" is the metric of interest.

On another topic: A key issue is what are the C:N:P ratios in the macro-algae export relative to the background organic carbon export. For the macroalgae C:N is 20 and C:P is 111, so that is C:N:P to be 111:5.6:1.

I don't think you report the C:N and C:P ratios for the plankton export. I think Eby et al 2012 that you cite uses 106:16:1.

I am going to guess that the main reason that the macroalgae does something is because you can export 20 molC for each molN with the macro-algae but only 6.6 molC for each molN with phytoplankton. Is this understanding correct?

If so, why don't phosphate constraints govern? The 111 vs 106 differs by less than 5%. So why does using macroalgae give you only a 5%.

I guess my main issue with this paper on a superficial quick read is that I do not understand why the authors got the result that they got.

1. What if the Redfield ratios of the macroalgae were the same as the Redfield ratios of the phytoplankton? Would the macroalgae then be effective?

2. What if the remineralization depth of the macroalgae were the same as that of the phytoplankton? Would their macroalgae then be effective?

In short, and I admit a superficial reading, I don't understand why you obtained the results you obtained.

A good thing to ask yourself in any modeling study is: What assumption would have to be false to lead to a qualitatively different conclusion? This is often a good way to state the factors that are critical to your conclusions and what features of your model are additional ornamentation not central to your result.