

Ocean Sci. Discuss., referee comment RC1
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Comment on os-2021-75

Anonymous Referee #1

Referee comment on "There and back again, a journey of many pathways: conceptualising the marine organic carbon cycle" by Maike Iris Esther Scheffold and Inga Hense, Ocean Sci. Discuss., <https://doi.org/10.5194/os-2021-75-RC1>, 2021

Review of Scheffold & Hense, "There and back again, an organic carbon journey: mapping pathways and loops"

Summary:

The manuscript presents a conceptual modelling framework for describing the pathways taken by organic and inorganic carbon through the ocean and its sediments. The framework is explicitly non-quantitative and its authors emphasise its use as a way of understanding how carbon is circulated between reservoirs and along pathways in the ocean, particularly where the latter lead to carbon "loss" to the atmosphere or geological reservoirs. The framework essentially divides the carbon cycle into organic and inorganic pools, with further distinctions made for specific dissolved organic carbon pools. By focusing on the entirety of potential pathways, one aim of the manuscript is to draw attention away from those specific pathways that typically focus attention (e.g. the biological pump).

Overall, while I am intrigued by the manuscript, and can envisage how its insights might be used, I cannot currently recommend it for publication. By being presented in a highly abstracted way, and by avoiding specific examples of its use, it feels as if any potentially interested users still have a mountain to climb. I do understand why the authors have made these choices for the manuscript. However, I suspect most readers will find the concept of interest, but will be dissuaded from pursuing it because it is unclear what next steps are needed to make best use of it.

In terms of its revision on this point, what I think would help it be more clearly relevant is its use in an example. From my own area – global-scale marine biogeochemical modelling – I could see it potentially providing a framework for identifying and, more importantly, **quantifying** major carbon flows between different models and, potentially, observations. In this way, the details of individual models could be ignored to focus instead on major pathways, including how these change across simulations of the present and future. Adapting the manuscript to include a clear instance of the use of its conceptual framework feels necessary to me.

My recommendation is that the manuscript is returned to the authors for major revision centred around my above criticism. I have a number of more minor comments and criticisms listed below.

On Ocean Science's specific questions:

Does the paper address relevant scientific questions within the scope of OS?

- Yes; at least potentially

Does the paper present novel concepts, ideas, tools, or data?

- Yes; certainly a novel conceptual tool

Are substantial conclusions reached?

- The paper does not lend itself to simple conclusions

Are the scientific methods and assumptions valid and clearly outlined?

- Generally yes

Are the results sufficient to support the interpretations and conclusions?

- It's not this sort of paper to be honest

Is the description of experiments and calculations sufficiently complete and precise to allow their reproduction by fellow scientists (traceability of results)?

- I believe so

Do the authors give proper credit to related work and clearly indicate their own new/original contribution?

- Yes

Does the title clearly reflect the contents of the paper?

- It could be clearer; for instance: "There and back again, an organic carbon journey: *a conceptual model for* mapping pathways and loops"

Does the abstract provide a concise and complete summary?

- Yes

Is the overall presentation well structured and clear?

- Yes

Is the language fluent and precise?

- Yes; with a few minor slips

Are mathematical formulae, symbols, abbreviations, and units correctly defined and used?

- Yes

Should any parts of the paper (text, formulae, figures, tables) be clarified, reduced, combined, or eliminated?

- Table 3's presentation of the conceptual model's "language" is necessary, but it seems very clunky (see comments below); I don't know how this can be avoided, however

Are the number and quality of references appropriate?

- For what the authors are proposing, yes

Is the amount and quality of supplementary material appropriate?

- Yes

Minor comments:

Abstract: the manuscript would do well to make clear somewhere that ocean uptake of anthro CO₂ has little to do with the biological focus of this manuscript; the opening statement of the abstract is implying that the reverse is true

Abstract: recalcitrant DOC is poorly defined at this point; this might not matter for the framework here, but the authors should note the work of Arrieta et al. (2015; <https://doi.org/10.1126/science.1258955>) on the bioavailability of low concentrations of DOC molecules

Abstract: regarding the absence of applications in this manuscript, one use this qualitative approach could be put to is creating a systematic structure of the ocean's carbon cycle that quantitative datasets or models can be aligned with; that would simplify both obs and models to allow simple comparisons of reservoirs and fluxes

Pg. 1, ln. 16-18: this sentence is confusing; what does "it is the first concept" mean?; models of the marine system are not always structured around e.g. export; also, the span of processes here is already covered in some models; so it's unclear why this framework is special

Pg. 1, ln. 18-19: point 1 is good; it's what I've identified above; point 2 is also good, although it doesn't introduce anything new on this point; models usually include all of these exit points because they have to; in Earth system models, for instance, the budgeting of C is critical, so these exits are explicitly there (and usually monitored diagnostically)

Pg. 1, ln. 20-21: It **needs** to be quantitative if it's to help here; being qualitative and abstracted to basic processes will reduce its usefulness

Pg. 2, ln. 28-29: But pathway options are already explicitly included in quantitative models; those move C between different reservoirs, and between locations in the case of 3D models; the conception and representation of the biological pump and its elevation of interior ocean CO₂ is arguably already a "general pathway"

Pg. 2, ln. 31: "inter alia" is a relatively uncommon latin expression; it might be better to replace with "among other things" for non-native English speakers

Pg. 2, ln. 31-33: bit of bracket indiscipline here

Pg. 2, ln. 44: is it unclear?; in the case of migrating animals, living organic material is returned; in the case of mixing, either dissolved inorganic or organic C is returned

Pg. 2, ln. 45: remineralisation is effectively the respiration of organic carbon to inorganic DIC by bacteria or other microbes; respiration more or less by definition turns organic C into inorganic CO₂

Pg. 2, ln. 48-50: this sounds like the authors are trying to give a more holistic description of the marine carbon cycle, but it is unclear how this will be achieved

Pg. 2, ln. 54-55: studies typically focus on individual processes either because observational data refers to these processes, generally where they are judged the dominant process in a given situation; also as studies are typically of finite length, focusing on particular pathways is necessary; perhaps by being clearer here on the alternative being proposed will help

Pg. 3, ln. 59-60: this is getting a bit opaque now; also, the export arrow is necessarily thinner at depth because there is simply less material the deeper one goes - this is a simple function of material being added only at the surface

Pg. 3, ln. 66-68: again, this sounds like it is merely making a case for a more holistic treatment of the C cycle, i.e. everything including the kitchen sink; noting that models, including conceptual ones, truncate the real world does not seem all that novel a point to make; and, as already noted, some models already go quite far towards including as much detail as is known

Pg. 3, ln. 81: what about dissolved inorganic carbon?; it's only the largest ocean reservoir

Pg. 3, ln. 82: So ... straightaway some real-world detail is being dispensed with?; that sounds a little less than holistic

Pg. 3, ln. 84: you might want to be very clear on what you mean by "species" here; it's obviously not "biological species", but it also appears not to be "chemical species" either; it's somewhere in between

Pg. 3, ln. 85-85: any explanation for these arbitrary size limits?

Pg. 3, ln. 88: again, rDOC may not be recalcitrant at all, merely at low concentration

Pg. 3, ln. 88: 1.5 to 40,000 years is quite a span; again - any explanation for these

arbitrary timespan limits?

Pg. 4, ln. 91-92: you could note that very few models go to the bother of subdividing DIC into its constituent species

Pg. 4, ln. 99: the use of "particle" here might be confusing; in a marine context, this could mean an actual particle of marine snow

Pg. 4, ln. 105-109: this is a big ask; if the conceptual model is not going to be quantitative, it has to do something special qualitatively to compensate; the introduction here has not made it clear what

Pg. 4, ln. 108: "a delay of consumers"?; this is opaque; I think it would make more sense if "a delay of" was deleted; however, I may be misunderstanding what "delay" means here

Pg. 4, ln. 111: "bases" -> "is based"

Pg. 4, ln. 112: "non-exclusive"?; this might need a clarifying remark - suggesting that a review was non-exclusive implies that it read **all** of the literature

Pg. 4, ln. 115-118: OK, this sounds good so far; obviously I'm immediately wanting to assign numbers ...

Pg. 4, ln. 121: "under the given hygiene conditions"?; this is a strange qualifier to add without explanation; is this an oblique reference to the ongoing pandemic?; in any case, either explain or delete

Pg. 4, ln. 121: "example" -> "analogy"

Pg. 5, ln. 138: "position change" is an interesting one given that this can have radically different drivers; it can be physical, biological-gravitational, biological-migrational, etc., each of which can have distinct consequences; for instance, dissolved OC moved by physics will not interact with sediments in the same way as OC sinking gravitationally; is this a problem?; by having multiple OC routes out of the surface, the diagram would suggest possibly not, but then is opaque on what these different routes cover

Pg. 5, ln. 150: quite; per my previous point

Pg. 6, ln. 155: SLS = "surface layer space"?

Pg. 6, ln. 154-164: sensible spatial breakdown

Pg. 6, ln. 167: SRL -> SLRL; per SLS?

Pg. 6, ln. 167-176: this makes sense, but one has to concentrate with all the acronyms; I've two suggestions here; 1. maybe parse out the examples with in-line "equations" of flow pathways; i.e. SLS -> WCS -> SLS; 2. it feels like you need a syntax for using all of these space, process, pathway interactions - yes, you can write sentences with them, but having a consistent way of writing them might make it easier to follow what a particular example is doing

Figure 1: as already noted, the significance ascribed here to rDOC formation is perhaps misplaced given that rDOC might only be recalcitrant because individual chemical constituents are at low concentration; the predominance of this process in this model seems disproportionate given that potentially more quantitatively important processes are downgraded and lumped into "OC remineralisation"

Pg. 14-16, Table 3: while this table tries to address a point I made earlier about allowing a consistent description of the pathways, the result seems very clunky to me; I can't immediately envisage a clear alternative, to be fair

Pg. 14-16, Table 3: might a good example "process" for the breakdown illustrated here be

the biological pump itself?; by looking at this, the authors could (a) give an example of how conventional understanding of a carbon cycle process can be translated into their conceptual model, and (b) illustrate the difficulties of doing so because of the associated complexity, and (c) thus emphasise the importance of a holistic viewpoint

Pg. 17, ln. 298: most existing models already incorporate this cyclic aspect; what's special here?

Pg. 17, ln. 299-301: this sentence may describe how the process of export is *sometimes* described, but I think it's an exaggeration to suggest that this is "normal"; most modelling scientists are well aware of return pathways; to be honest, return pathways can even be highly visible at the surface, e.g. CO₂ outgassing along the equatorial Pacific

Pg. 17, ln. 301-303: being (as the authors keep stressing) purely qualitative, the conceptual model under discussion here cannot really help with this point much more than making it clear (which may, as already noted, be obvious for many researchers) that "what goes down must come up"

Pg. 18, ln. 342-345: where this conceptual model seems useful to me is in pointing to fluxes, and making it clear where they sit in a wider consideration of the cyclic pathways of carbon