

Reviewer 2

Review of `Seasonal cycles of the carbon export flux in the ocean: Insights from the SISOOMA mechanistic model` by Kandylas and Visser

Kandylas and Visser present a study using SISOOMA, a model previously published as a preprint by Visser et al. (2024), to explore the seasonal cycle of carbon export flux in the ocean. The model simulates marine aggregates, including their size and excess density, resulting in a time-varying sinking speed. The authors conduct several sensitivity analyses related to particle stickiness, remineralization, and size–excess density characteristics. While the main focus is on the seasonal cycle of the carbon flux, the study also analyzes the s-ratio and its relationship to parameters.

I found the paper well-organized and relevant to important research areas concerning particulate organic carbon and its fate in the ocean. I particularly appreciated the authors' discussion (could be expanded) on how this type of modeling framework can be implemented in more complex ocean biogeochemical models, which are commonly used to study metrics such as the e-ratio and s-ratio.

The manuscript is well written and follows a logical structure with clearly defined sections: Introduction, Methods, Results, and Discussion. It is generally understandable and well presented. However, some points should be addressed or corrected before being considered for a publication. These are outlined in detail below.

I have one major comment: the SISOOMA (v1) model was already published as a preprint by the same authors in November 2024. It would be helpful if the manuscript clearly states whether this study is an application of the previously developed tool or if there are significant updates or developments to the model specific to this study. This clarification is necessary, especially since some parts of the manuscript (e.g., Eq. 3 and model descriptions) appear to be very similar to the preprint.

First , we would like to thank the reviewers for their useful feedback and time spent into reviewing this manuscript.

The "Visser et al" paper was a pre-print and now it is removed from our references. For this reason, we expanded the methodology part of this manuscript.

The analysis in sections 3.1 and 3.2 are based now in a different seasonal cycle, see Fig. 2.

Introduction

- **Line 28:** “PPoM “is not introduced before it is used.

Fixed. ‘the first being the relationship between PNPP and PPOM which is the production rate of primary particulate organic material’

- **Line 35:** I suggest moving this equation to the Methods section. It can also be given as a written description. Since it is one of the equations used in the analysis, presenting it in the Methods would be more appropriate.

We would like this equation to be in Introduction since the whole manuscript is built around the idea about distinguishing e-ratio from s-ratio.

- **Line 44:** A parenthesis is needed before “e.g.” Fixed
- **Line 70:** (Visser et al.,) — the year is missing, and the DOI is also missing from the references. I believe it is critical to cite this reference correctly, as the model used in this application was described in 2024. The same issue appears elsewhere in the manuscript and should be corrected throughout (I won't point them all out individually).

The "Visser et al" paper was a pre-print and now it is removed from our references. For this reason, we expanded the methodology part of this manuscript.

Methods

- **Line 87:** The statement starting with “In principle, ...” belongs more in the Discussion section. In the Methods, the focus should be on describing what has actually been done.

Fixed

- **Line 101 – Eq. 3:** This equation is the same as Eq. 8 in Visser et al. (2024), where it is explained more clearly. I’m not suggesting it needs to be copied word by word, but the explanation could be improved in this version by referring to that paper (depending, of course, on the publication status of the preprint).

We expanded the methodology part, improving the flow and describing all relevant parameters

- **Figure 1:** It would help the reader if the axis labels indicated whether x and y are scaling factors.

Added better description of x, y in the figure captions and methodology

- **Line 144:** “Throughout the report” — I think you mean manuscript. I suggest using `manuscript` instead of `report`.

Changed to ‘Throughout this analysis’

- In the same paragraph and following equations, there are some inconsistencies. For example, it's unclear what a, b, c refer to — please use equation numbers for clarity. Also, Eq. 6 is the s-ratio, but in the text, it is described as F_{tot} . These should be carefully checked.

Fixed

- **Lines 155–160:** This section seems more appropriate for the Introduction rather than the Methods.

Removed

Results

- **Line 163:** The subheading “Model Mechanics” is clear for a modeller, but for a broader audience, it would be helpful to provide a more descriptive title that reflects the narrative of Figures 4 and 5.

Changed to ‘Model analysis’

- **Figure 4:** The blue line in panel (a) needs a legend. Additionally, the meaning of the black dot in Figure 4d should be included in the figure caption — I assume it represents the annual mean, as indicated in the caption of Figure 5.

Added description of the black dot

We don't use a legend for the blue line, because it matches the color of the left x-axis. However, we state it now in the legend for clarity.

- **Figure 6:** In the caption, I assume P stands for PPOM.

Fixed

- **Line 226–227:** The reference to Figure 5 should be placed in parentheses.

To be consistent with the rest of the manuscript, we refer to the figures without using parentheses. We changed it to Figs. 5(e,f).

Discussion

- **Line 293:** “SISOMA provides modeling... mixed layer” — but throughout the study, 100 m depth is used. Since the mixed layer depth varies seasonally, was this variability accounted for in your application? I think it is important to be consistent and clear.
 - Even though we use the term ‘stratification’, we keep the mixed layer depth constant at 100m. The ‘stratification’ scenario changes only the turbulent dissipation rate.
 - Added paragraph: ‘It is important to mention that, in the context of this project, in the seasonally stratified scenario only the turbulent dissipation rates varies with time, while the mixed layer depth remains constant at 100m throughout the annual cycle in all simulations.’ (line 145 of revision)

- Added new paragraph in the discussion about the seasonal variability of the mixed layer depth (line 404-411 of revision)
- Added clarification in the caption of figure 3
- **Line 296–297:** Misspelling: “remineneralization” should be corrected to “remineralization”.

Fixed

- **Figure 9:** This is a very well-presented summary figure that nicely communicates the manuscript's story and conclusions. Therefore, it can be used as a guide while reversing manuscript's method and result section. It also provides a helpful framework for the community. It shows the relative importance of remineralization, aggregation, fragmentation, and sinking during the three phases of carbon export. However, I was a bit confused about the arrows and Ccirt. Figure would benefit to revising of them.
 - Modified arrows. We keep the same length and the width indicates the relative importance of each process and stating that the arrows point towards the direction where mass is forced to move under the effect of each process
 - Improved captions
- **Line 421:** This is a good aim/paragraph and could be expanded further. The first sentence of the paragraph, in particular, would benefit from being supported by a reference - for example, Henson et al. (2019), which is already included in the reference list. There is relevant literature on this topic, and incorporating additional references would help strengthen the authors' argument. In my opinion, this part of the discussion would benefit from integrating more references.

We added the proposed reference. We would like not to expand on this point though to keep the discussion concise and use all this information for the next manuscript where we couple SISSOMA to NUM plankton trait-based model.

Reference

Visser, A. W., Almgren, A. V., and Kandylas, A.: SISSOMA (v1): modelling marine aggregate dynamics from production to export. h