Review of the manuscript *Tracing the contribution of dust sources on deposition and phytoplankton carbon uptake in global oceans* by Y. Liu and co-authors

The manuscript by Liu et al. (2025) presents a comprehensive modeling study investigating the contribution of atmospheric dust deposition to marine phytoplankton carbon uptake across global oceans. The research provides a quantitative evaluation of the dust source (land) and sinks (ocean) and estimates its potential fertilisation effect. These results are achieved by firstly refining the iron solubility in the model Community Earth System Model (CESM). Secondly, authors estimate the phytoplankton carbon uptake associated with dust deposition employing the iron to carbon stochiometric relationships (Fe:C ratios) based on the approach by Wiseman et al, 2023.

The main estimates for dust and soluble iron (global dust deposition supplies 11.1 Tg yr^{-1} of total iron and 0.4 Tg yr^{-1} of dissolved iron to oceans) are in line with previous research while the estimates of dust-induced carbon uptake (5.6 Pg C yr^{-1}) shows some discrepancies with recent literature (Westberry et al, 2023).

The manuscript provides interesting and relevant new insights into the regional and seasonal distribution of dust emissions and deposition. However, the results on phytoplankton carbon uptake linked to dust are less convincing and require some additional work to accept the manuscript for publication.

General comments

The main general comment I have is the need for an accurate estimation of uncertainties associated with interpolating limited observational databases to the global ocean. Interpolated maps of dFe and solubility are impacted by mathematical artefacts (e.g., longitudinal lines in the North Pacific or latitudinal band in the Indian Ocean in Fig. S1 and S2) with spatial patterns that do not follow regional biomes (Henson et al, 2010) nor major dust transport pathways. Applying a flexible Fe:C ratio on top of these heavily interpolated observations results in an overlap of uncertainties and potential error propagation that strongly weakens conclusions. In the current approach, the accuracy improvement associated with observational databases might be lost due to interpotion. In the way the manuscript is currently presented, this issue is critical because it directly impacts the dust-induced carbon uptake estimates.

Two potential alternative amendments to the manuscript:

1. Simply focus on the dust distribution from land sources to oceanic regions. This part of the manuscript holds interest on its own, although it will require additional content and some minor improvements to ease readability (see Other Comments section)
2. In order to include dust-induced carbon uptake estimates, authors need to rethink the observational approach. The estimates could, for instance, be focused on the bioregions where observations are abundant. Or apply a more sophisticated interpolation method that takes into account the oceanic biogeochemical regions and their seasonal dynamics. The results of this hypothetical approach would need to be validated against subsampled observations not used in the interpolation or/against modelling estimates of solubility and dissolved Fe (Hamilton, Moore et al, 2020, Bergas-Massó et al, 2023). Based on these analyses, maps should always include spatially variable uncertainty estimates or at least mark where results are statistically uncertain.

A last general comment is that this study focuses only on dust but uses a flexible Fe:C approach developed in a model including other aerosols, from pyrogenic or anthropogenic sources, which are known to contain Fe in highly soluble forms (Hamilton, Moore et al, 2020). These non-dust contributions are also naturally included in observations, where differentiating between aerosol sources is very challenging. If the inclusion of non-dust aerosols is not possible, authors need to acknowledge this limitation and propose hypotheses on how their results might be affected by it.

Other comments

<u>Dust transport and deposition</u>

- The regional division of dust sources is very useful and provides interesting results when linked with the oceanic regions. However, this regionalisation generates 20 different acronyms that make the reading arduous. I'm unsure how this could be solved, but maybe using more explicit acronyms, reducing the number of them (or focusing on the most relevant ones).
- Figure 7 is for me one of the most interesting results of the manuscript. However, its repetition for each season (Fig 8) is excessive and very hard to follow. I'd suggest moving Fig 8 to Supplementary Material. Additionally, it would be very interesting to capture the

most important seasonal dynamics and show them in a figure or the text, to understand where and why sources-to-sink links change from one season to another.

- Related to the previous comment, is it possible to also analyse interannual variability?

Biological response

- The study could strongly increase its relevance by including some additional diagnostics related to the use of a flexible Fe:C or non-constant Fe solubility values. For instance, how does carbon uptake change when using a constant Fe:C or Fe solubility?
- L646 The discrepancies with Westberry et al, 2023 should be explicitly addressed, providing hypotheses on the sources of such discrepancies.

Thank you!

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