This is an important topic to better understand and potentially quantify the effect/amount of transported particles by ocean currents while sinking from the ocean surface to the sea-floor and forming an archive for paleorecontructions.

This process is hardly taken into account or discussed in the scientific reconstructing past ocean conditions which explains why the paper by [12] is hardly cited and surprisingly not taken up in the list of references in this manuscript. Please allow me to quote his first sentence from the abstracts:

'The interpretation of micropaleontological data based on the fossil remains of planktonic organisms requires an appropriate reference frame.'

Several papers have been published since then reporting observations and/or attempts to quantify this effect [2, 7, 8] where this particles are sometimes called expatriates. To my knowledge a paper modelling this effect and quantifying the consequence for the sediment composition is still missing, while much more articles concentrate of vertical mixing (bioturbation) in sediments, a process which changes the original composition of surface ocean sediments (including the expatriates).

An extreme effect of this kind of process on particles in the micro- to nano-scale is reported by [6] and the effect on establishing an age frame of marine sediments by radiocarbon dating.

This paper nicely clusters deep-sea sediment uses a 3D-flow model to shed more light on the complexity of the sedimentary microplankton composition.

Although not being an experts in statistics and modeling, the used methods sound carefully selected and applied.

The text is very well written and explanations are sound and convincing.

We would like to thank Gerald Ganssen for his careful reading and his constructive comments.

Please find our replies and our proposed changes in the revised manuscript below.

On behalf of the authors,

Peter Nooteboom

Changes in manuscript

The papers [12, 6, 2] will be referred to in the introduction section and [12] will also be referred to in the discussion section of the new manuscript version.

In the method section the authors do not mention the typical size fraction for their calculated sinking speeds of both dinoflagellate cysts and planktonic foraminifera; here it would be important to make a difference between empty shells and those still containing organic material which, during sinking, will get oxidized and the amount of gas within the shell will reduce sinking speed siginificantly.
A discussion on the potential effect of very slowly sinking particles reaching the sediment archive: How high do the authors estimate this bias?

Author's response

In general, the processes that influence the sinking speed of marine particles are complex (in particular due to particle aggregation and fecal pelleting). Therefore, we do not test specific sinking speeds for different microplankton species. Instead, we use four constant sinking speeds (6, 11, 25, 250 m day^{-1}; see the Supporting Information), and find that the clustering structure is not sensitive to sinking speed, because of the similar spatially varying character of ocean advection that particles experience at these sinking speeds (L.174-178 and L.240-249 of the manuscript). Because the clustering structure is to first order independent of the sinking speed, it is irrelevant to add information on the size fractions and distinguish between empty shells and those that include organic material.
We consider 6 m day^{-1} to be a low sinking speed for both planktic foraminifera and dinoflagellate cysts (dinocysts). We did not test lower sinking speeds, because the back-tracking analysis is computationally infeasible for 'very low' sinking speeds due to long particle travel times.
Hence, we will not include a discussion on the effect of 'very low' sinking speeds on the clustering structure.

Changes in manuscript

We will add a sentences in the method section to explain why we do not test lower sinking speeds (L.59):
Sinking speeds lower than 6 m day^{-1} can occur (e.g. due to oxydation of organic material and the development of gas within a shell), which may have an effect on the computed clusters. However, sinking speeds lower than 6 m day^{-1} are not tested in this paper, because the backtracking method is computationally infeasible at lower sinking speeds due to long particle travel times.

To further prove the applicability of the authors approach they should compare their results with selected case studies from literature, where lateral advection of sinking particles has been reported to contribute to the sediment association and might disturb the original surface ocean signal.

Author's response

Comparison of the back-tracking analysis with specific case studies has already been done (e.g. [8, 11]). In order to rigorously compare our clustering results to other types of data than surface sediment sample sites, an extended dataset of microplankton at or near the ocean surface is required. For dinocysts, this dataset does not exist to our knowledge, because the

biological producers of dinocyst species (i.e. the dinoflagellate species) are often not known. For planktic foraminifera, the sediment trap data from [3] cannot be used, because most data is not from the near-surface, but from sediment traps at greater depths.
Hence, no dataset is available to make such a comparison.

Changes in manuscript

None.

Finally:
I do not see how:
These type of studies could determine the relative contribution to the higher biodiversity outside compared to within oceanographically isolated clusters from ocean surface parameters, as well as dissolution [1, 10] and mixing of particles during their sinking journey. :

Author's response

Microplankton biodiversity as measured in sediment sample sites is determined by (a) microplankton biodiversity near the ocean surface, (b) species-specific dissolution and (c) mixing of species during their sinking journey. Microplankton at sediment sample sites in oceanographically isolated clusters are likely less influenced by (c) compared to the 'noisy' areas. Hence, oceanographically isolated clusters can be used to determine areas where lateral transport does not influence the biodiversity in sedimentary sample sites.

Changes in manuscript

We rephrase this paragraph in the discussion (L.298):
'Fourth, our study provides micropalaeontologists with a tool to qualitatively assess the importance of lateral transport to sedimentary particle assemblages, which can be used in studies that compare measured biological diversity and environmental conditions in surface waters with their sedimentary remains (e.g. [3, 5]), particularly in those regions for which we here demonstrate noisy behaviour~~. These type of studies could determine the relative contribution to the higher biodiversity outside compared to within oceanographically isolated clusters from ocean surface parameters, as well as dissolution [1, 10] and mixing of particles during their~~: Within oceanographically isolated clusters, sedimentary microplankton biodiversity is only weakly determined by lateral particle transport compared to the microplankton biodiversity near the ocean surface and species-specific dissolution [1, 10] .'

Detailed studies of productivity in surface mixing zones [9] probably might be much stronger than advection during the sinking of the particles. I hence would like the authors to more thoroughly explain this conclusion.

Author's response

This is a good point, and in particular true for planktic foraminifera which are passively advected at the near-surface during their life span. A paragraph in the discussion section explains

this point (L.305-310).
Near-surface mixing of dinocysts is not an issue. Immediately after being produced, dinocysts start sinking passively. If dinoflagellates (the biological producer of the dinocyst) end up outside of their habitat due to surface mixing, they die, oxidize and do not end up in the sedimentary record.

Changes in manuscript

We will rephrase this paragraph to make this point clearer and add the reference [9] (L.305): 'The backtracking analysis on which we applied the clustering was designed for dinocysts, and not for foraminifera. ~~Clustering results~~ In particular, near-surface advection during the foraminifera life span may have a larger impact on its sedimentary distribution compared to the lateral transport during sinking [9]. Clustering results from this paper compared well with the foraminifera dataset in most cases, because the areas with strong particle mixing and lateral transport (i.e. their spatial dependence) are likely similar for foraminifera (and likely similar at the near-surface compared to other depth levels). Nevertheless, future work could apply these clustering methods on a backtracking analysis which is designed for foraminifera (similar to [11, 4]). This means that particles are released at the ocean bottom, tracked back in time until they reach the foraminifera dwelling depth, and finally tracked back during their life span at this dwelling depth.'

References

[1] Ivy Frenger, Matthias Münnich, and Nicolas Gruber. Imprint of Southern Ocean mesoscale eddies on chlorophyll. pages 4781–4798, 2018.

[2] Gerald Ganssen and Dick Kroon. Evidence for Red Sea surface circulation from oxygen isotopes of modern surface waters and planktonic foraminiferal tests. *Paleoceanography*, 6(1):73–82, 1991.

[3] Lukas Jonkers, Helmut Hillebrand, and Michal Kucera. Global change drives modern plankton communities away from the pre-industrial state. *Nature*, 372, 2019.

[4] Michael Lange and Erik van Sebille. Parcels v0.9: prototyping a Lagrangian Ocean Analysis framework for the petascale age. *Geosci. Model Dev. Discuss.*, (July):1–20, 2017.

[5] Julie Meilland, Hélène Howa, Vivien Hulot, Isaline Demangel, Joëlle Salaün, and Thierry Garlan. Population dynamics of modern planktonic foraminifera in the western Barents Sea. *Biogeosciences*, 17:1437–1450, 2020.

[6] G. Mollenhauer, T. I. Eglinton, N. Ohkouchi, R. R. Schneider, P. J. Müller, P. M. Grootes, and J. Rullkötter. Asynchronous alkenone and foraminifera records from the Benguela Upwelling System. *Geochim. Cosmochim. Acta*, 67(12):2157–2171, 2003.

[7] P D Nooteboom, P Delandmeter, Erik Van Sebille, Peter K Bijl, Henk A Dijkstra, and Anna S von der Heydt. Resolution dependency of sinking Lagrangian particles in ocean general circulation models. *PLoS One*, 15(9):1–16, 2020.

[8] Peter D Nooteboom, Peter K Bijl, Erik van Sebille, Anna S von der Heydt, and Henk A Dijkstra. Transport Bias by Ocean Currents in Sedimentary Microplankton Assemblages : Implications for Paleoceanographic Reconstructions. *Paleoceanogr. Paleoclimatology*, 34, 2019.

[9] Janneke J Ottens and Alexandra J Nederbragt. Planktic foraminiferal diversity as indicator of ocean environments. *Marine Micropaleontology*, 19:13–28, 1992.

[10] Ben J Taylor, James W B Rae, William R Gray, Kate F Darling, Andrea Burke, Rainer Gersonde, Andrea Abelmann, Edith Maier, Oliver Esper, and Patrizia Ziveri. Distribution and ecology of planktic foraminifera in the North Pacific: Implications for paleoreconstructions. *Quat. Sci. Rev.*, 191:256–274, 2018.

[11] Erik van Sebille, Paolo Scussolini, Jonathan V Durgadoo, Frank J C Peeters, Arne Biastoch, Wilbert Weijer, Chris Turney, Claire B Paris, and Rainer Zahn. Ocean currents generate large footprints in marine palaeoclimate proxies. *Nat. Commun.*, 6:6521, 2015.

[12] P K Weyl. Micropaleontology and ocean surface climate. *Science*, 202:475–481, 1978.