Marine snow surface production and bathypelagic export at the Equatorial Atlantic from an imaging float

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Responses to the Reviewers' Comments

Answers to reviewers' comments are reported point by point. The questions and comments of the reviewers are in blue, the answers in black, and the modifications that we made in the revised manuscript in red.

Responses to the comments of the anonymous Reviewer 1

First, we would like to warmly thank Reviewer 1 for their relevant and constructive comments, which helped to improve the manuscript.

The study provides a comprehensive data set, observing and describing two export events in the equatorial Atlantic and key factors that may drive the observed carbon flux. They present details on particle properties such as their size and density. I think that is a valuable case study of how recent developments in underwater imaging technology can be used to gain detailed insights into carbon flux mechanisms. The data analysis and method description are clear and thorough.

Reply: We appreciate the positive assessment of Reviewer 1.

L44–56: Mineral ballasting could be mentioned as an additional factor

Reply: This will be added as following in the revised manuscript.

Mineral ballasting, through the association of marine snow with dense inorganic materials such as calcium carbonate, lithogenic or biogenic silica, can also significantly enhance sinking velocities and control the carbon export efficiency (Armstrong et al., 2002; Klaas and Archer, 2002).

L315: "best transfer efficiency" – rephrase to "highest transfer efficiency" to avoid a misleading qualitative assessment

Reply: This will be rephrased as suggested in the revised manuscript.

Section 3.4.1. I found this section difficult to read as five acronyms were introduced at once. In many points the authors make, there is a pattern by either size or by packaging. I would suggest spelling this out by describing the categories as either small or large, and either densely packed, loosely packed, or fiber. Also, I think that the word "porous" is misleading; I would suggest "dense" and "loose" or "dark" and "light", based on the image property. Example: "They shared similar temporal dynamics primarily in the surface layer: all types decreased exponentially between 0 and 150 m. While fibers and loose/light particles decreased slowly throughout the water column in the mesopelagic layers, dense/dark particles increased gradually between 400-600 m."

Reply: We thank the reviewer for this thoughtful comment. While we understand the concern about introducing multiple acronyms at once, we believe that the classification is important for distinguishing the five morphotypes, which reflect distinct features relevant to our analysis. We recognize, however, that the section may benefit from improved clarity. Rather than replacing the acronyms entirely, we prefer to retain them but will ensure that each is introduced with accompanying descriptive terms (e.g., small/large, dense/loose, or fiber-like) to improve readability.

Regarding the use of the term "porous," we acknowledge that interpretation can vary. However, we use this term to reflect specific textural characteristics observed in the images, and we are cautious about replacing it with terms like "loose", which may carry a different meaning. We note that Reviewer 2 may provide additional perspective on this point, and we prefer to consider all feedback collectively before making substantial changes to terminology or structure. We are open to further adjustments depending on the broader consensus across reviews.

The k-means clustering applied to the PCA coordinates helped us to distinguish between five marine snow morphotypes illustrated in Figure 5. Type 1 consisted of large, compact objects with an Equivalent Spherical Diameter (ESD)>0.8mm referred to as Big Dense Particles (BDP). Type 2 comprised elongated, thread-like objects termed Fiber particles (FP), and type 3 consisted of large bright, and porous objects referred to as Big Porous particles (BPP). Type 4 was mainly formed of dense, small, and circular objects: Small Dense particles (SDP), and type 5 consisted of small, bright, and porous objects: Small Porous particles (SPP). These five morphotypes were then used to characterize the distribution and composition of marine snow. It should be noted that the terms "porous" and "dense" refer to brightness, with "porous" indicating greater light transmission while "dense" denotes lower light transmission.

The morphotypes identified here are different than the clusters identified by Trudnowska et al (which are cited here). Discussing why different categories were identified in the context of this ecosystem would add value to the paper.

Reply: We agree that addressing the differences between our morphotype categories and the clusters identified by Trudnowska et al. (2021) would strengthen the manuscript. Trudnowska et al. categorized marine snow into five broad morphotypes (dark, elongated, flake, fluffy, and agglomerated), optimized for the Arctic environment, particularly to capture the high morphological variability across bloom phases and changing phytoplankton communities in marginal ice zones. Their emphasis was on temporal structural changes concerning Arctic bloom dynamics. In contrast, our study, conducted in the equatorial Atlantic, defines five morphotypes that we interpret as reflecting morphodynamic features specific to this region's ecological and physical context. We have now added a brief discussion to the revised manuscript noting that these differences likely stem from the contrasting environmental conditions and biological communities of the two ecosystems. We also highlight that both classification approaches offer complementary insights into marine snow structure and its role in export processes.

This is in contrast with what was observed for the Arctic system, where two successive blooms of different nature occur and are associated with different morphotypes. The first bloom was an ice edge bloom and was dominated by diatoms, while the second was ice-free and was associated with the presence of Phaeocystis, leading to agglomerated morphotypes and their slow settling compared to the first bloom (Trudnowska et al., 2021). These differences in morphotypes reflect not only contrasting environmental conditions between the Arctic and equatorial Atlantic but also distinct bloom successions and morphodynamic responses, supporting the idea that regional ecosystem characteristics shape marine snow structure and its role in export processes.

L434-435: In my experience, denser particles can also be more intact, larger pieces of organic detritus, or aggregated phytoplankton after a longer period of time. I think that it can't automatically be concluded that the main source of dense particles are fecal pellets.

Reply: We agree that dense particles can originate from multiple sources, including intact organic detritus or aggregated phytoplankton, especially after prolonged aggregation processes. In this context, our use of the term *potential* was intended to emphasize that these dense particles are not composed solely of fecal pellets. However, we recognize that the sentence may not have conveyed this clearly. In the revised manuscript, we have rephrased this sentence to explicitly state that dense particles may include various components beyond fecal pellets, to avoid any ambiguity. The manuscript was modified as follows:

As for dense particles, these may include fecal pellets produced by zooplankton feeding, as commonly reported in previous studies (Stemmann and Boss, 2012; Trudnowska et al., 2021), but they could also originate from other sources such as aggregated phytoplankton or phytodetritus (Alldredge and Silver, 1988; Guidi et al., 2009).

L482: How much of the organic matter reached those depths?

Reply: We have now calculated the quantitative estimates to clarify how much organic matter reached the deep ocean. Specifically, Kiko et al. (2017) reported fluxes of approximately 2.07 mg C m^{-2} d^{-1} reaching depths of up to 4000 m. We have included these values in the revised manuscript to provide a clearer context for the magnitude of deep flux.

Figure 6: Would it be possible to reflect the patterns you see in particle size in this figure?

Reply: We thank Reviewer 1 for the helpful suggestion. We agree that incorporating visual cues related to particle size would improve the clarity of Figure 6. However, the figure is already quite dense, and illustrating each particle size in detail would further overcrowd it. In the revised version, we clarified in the figure's caption that the particle composition remains consistent between export and non-export events, and that the key difference lies in the concentration of particles rather than their size. While the figure already reflects these differences in concentration, we will explicitly state that both small and large particles can form dense aggregates, which are responsible for export, and that porous particles represent both the small and the large-sized particles to avoid any confusion regarding the role of particle size.

The new caption is:

Figure 6: Illustrative example of the particle export system in the Atlantic equatorial region during export and non-export events. FP: fiber particles, PP: porous particles, DP: dense particles. Teff: Transfer efficiency, Eeff: Export efficiency, TIW: Tropical instability Wave. We do not distinguish between small and large particles, as the particle composition remains consistent across both export and non-export events and only the concentration changes.

Code availability

I think it would be helpful for the scientific community and enhance the transparency of the dataset to share the code in the supplement or on a platform such as GitHub rather than making the reader rely on direct communications with the authors.

Reply: We agree with Reviewer 1; the code will be made available on GitHub to ensure accessibility and reproducibility.