

We thank Referee #1 for their constructive review of our manuscript. We appreciate the time and effort devoted to evaluating our work. We respond to comments (shown below in blue text) individually and outline subsequent changes that will be made to the manuscript (shown in black text).

The manuscript presents an analysis of ship-based data that are used to evaluate the contribution of different phytoplankton size classes to total chlorophyll concentration in the northwestern Weddell Sea region of the Southern Ocean. The work is well-written and thorough and the authors have considered a variety of methods in their modeling of different phytoplankton size classes, and total chlorophyll concentration from reflectance measurements. The manuscript is an effective contribution to the body of knowledge on phytoplankton ecosystems in a specific region of the Southern Ocean.

RESPONSE: We are pleased that you found the manuscript to be well written and thorough, with the potential to make a valuable contribution to our understanding of phytoplankton ecosystems in this region of the Southern Ocean.

Main comments:

As a reader I am curious how the regional-specific methods to separate size classes from satellite data would be relevant to other regions of the Southern Ocean; recognizing that the data are specific to the northwestern Weddell Sea, but it does beg the question of whether the differences observed between AMT and PICCOLO/Rothera also apply to other parts of the high latitude Southern Ocean? Maybe the authors could comment on the recommended use of the size class equations (i.e., should application of the Table 2 to satellite OC data be limited to the geographic region shown in Figure 6?). Relatedly, it could be worth commenting on, if not showing, how different the satellite maps look when using the tuned PICCOLO coefficients vs previously published coefficients (or the standard Chl-a algorithm for total Chl-a).

RESPONSE: We appreciate the reviewer's curiosity on whether the three-community model parameters in the northwestern Weddell Sea would be relevant, or applicable, to other regions of the Southern Ocean. Additionally, on how different the satellite maps may look when using previously published coefficients. We address these two points separately below.

Relevance to other areas in the Southern Ocean: To confidently address the question raised on whether the three-community model parameters in the northwestern Weddell Sea would be relevant, or applicable, to other regions of the Southern Ocean, would require compiling existing measurements, and collecting additional measurements, using exactly the same methods (size-fractionated filtration (SFF) based techniques), and evaluating whether the parameters hold, in the different region of the Southern Ocean. As this work is yet to be done (but would certainly be a useful next step), we would recommend against using model parameters tuned to the northwestern Weddell Sea, in other regions of the Southern Ocean, without conducting an independent evaluation.

However, other studies have reported similar findings in other regions of the Southern Ocean. For example, both Ward (2015) and Sun et al. (2023) studied the impact of temperature on the dynamics of the three-community model, reporting significant changes in model dynamics with temperature, with much higher fractions of nano- and microphytoplankton (lower for picophytoplankton) in low temperature waters. Sun et al. (2026) also calibrated the three-component model using a larger dataset, representative of both the broader Southern Ocean and tropical oceans, composed primarily of HPLC based estimates of size structure (rather than SFF methods). Whereas it is difficult to compare model parameter values directly with ours, when they have been derived using very different methods (see discussion in Brewin et al. 2014), similar patterns emerge in their analysis,

with much lower fractions of picophytoplankton and higher fractions of nanoplankton in Southern Ocean regions, over a broad range of total chlorophyll-a concentrations, when compared with tropical ocean regions.

Considering the comment raised, the following text will be added to the discussion of the manuscript (at lines 392 of the submission) to highlight these points.

The low contribution of picophytoplankton to total Chl-a has also been observed in other regions of the Southern Ocean (Ward, 2015; Sun et al., 2023, 2025). *“In fact, Ward (2015) and Sun et al. (2023) studied the impact of temperature on the dynamics of the three-community model, reporting significant changes in model dynamics with temperature, with much higher fractions of nano- and microphytoplankton (lower for picophytoplankton) in low temperature waters. Sun et al. (2026) recently calibrated the model using a larger dataset, representative of the broader Southern Ocean, composed primarily of HPLC based estimates of size structure. Although it is difficult to compare model parameter values directly when they have been derived using different methods (see discussion in Brewin et al. 2014), similar patterns emerge in their analysis, with much lower fractions of picophytoplankton and higher fractions of nanophytoplankton in Southern Ocean regions, over a broad range of total chl-a concentrations, when compared with tropical oceans. Nonetheless, we would recommend against using model parameters tuned to the northwestern Weddell Sea, in other regions of the Southern Ocean outside that of the Weddell Sea and Antarctica Peninsula, without conducting an independent evaluation using data from this region.”*

Satellite maps using previously published coefficients: We agree with the reviewer that satellite maps will look very different when using the previously published coefficients, representative of lower latitude waters, and the standard Chl-a algorithm for total Chl-a. We can easily demonstrate this by reproducing Figure 6 of the manuscript (see Figure R1 below), using standard Chl-a product (from OC-CCI) for total Chl-a and model parameters reported for AMT data (Table 2 of the paper), with the *in-situ* data overlain from PICCOLO. Clear differences emerge between the *in-situ* data and satellite data, in particular, for nano- and picophytoplankton fractions (Figure R1c and R1d).

Figure R2a shows the median percentage difference in the satellite maps between the standard Chl-a product from OC-CCI (Figure R1a), and the regional algorithm of Ferreira et al. (2022) (Figure 6a of the paper). The median of this value over the entire image is 37%, indicating the regional algorithm produces around 37% higher Chl-a than the standard Chl-a product from OC-CCI. Figure R2b-d shows the absolute differences in the satellite maps (Figure R1 and Figure 6), for the fractions of the three size classes. The median of these differences is 0.17 for micro, 0.36 for nano and -0.52 for pico. Figure R1 and R2 clearly demonstrate how different the satellite maps look when using standard Chl-a products and coefficients tuned to lower latitude regions (as in previous publications).

Considering the comment raised, the following text will be added to the discussion of the manuscript (at lines 412 of the submission) to highlight these points.

“We reproduced regional maps of total Chl-a and size fraction (not shown) using the standard OC-CCI total Chl-a product, and model parameters reported for AMT data (rather than PICCOLO), and compared these maps with the regional algorithms (Fig. 6). Large relative differences in total Chl-a (37% higher for the regional algorithm) and size fractions (median absolute difference of 0.17 for micro-, 0.36 for nano- and -0.52 for picophytoplankton) were found, demonstrating the importance of using regional models in the Weddell Sea and around the Antarctic Peninsula.”

Additionally, if the reviewer feels strongly that we should include the figures in the revised manuscript, we can or refer the reader of the main article to this response, which will be published alongside the article.

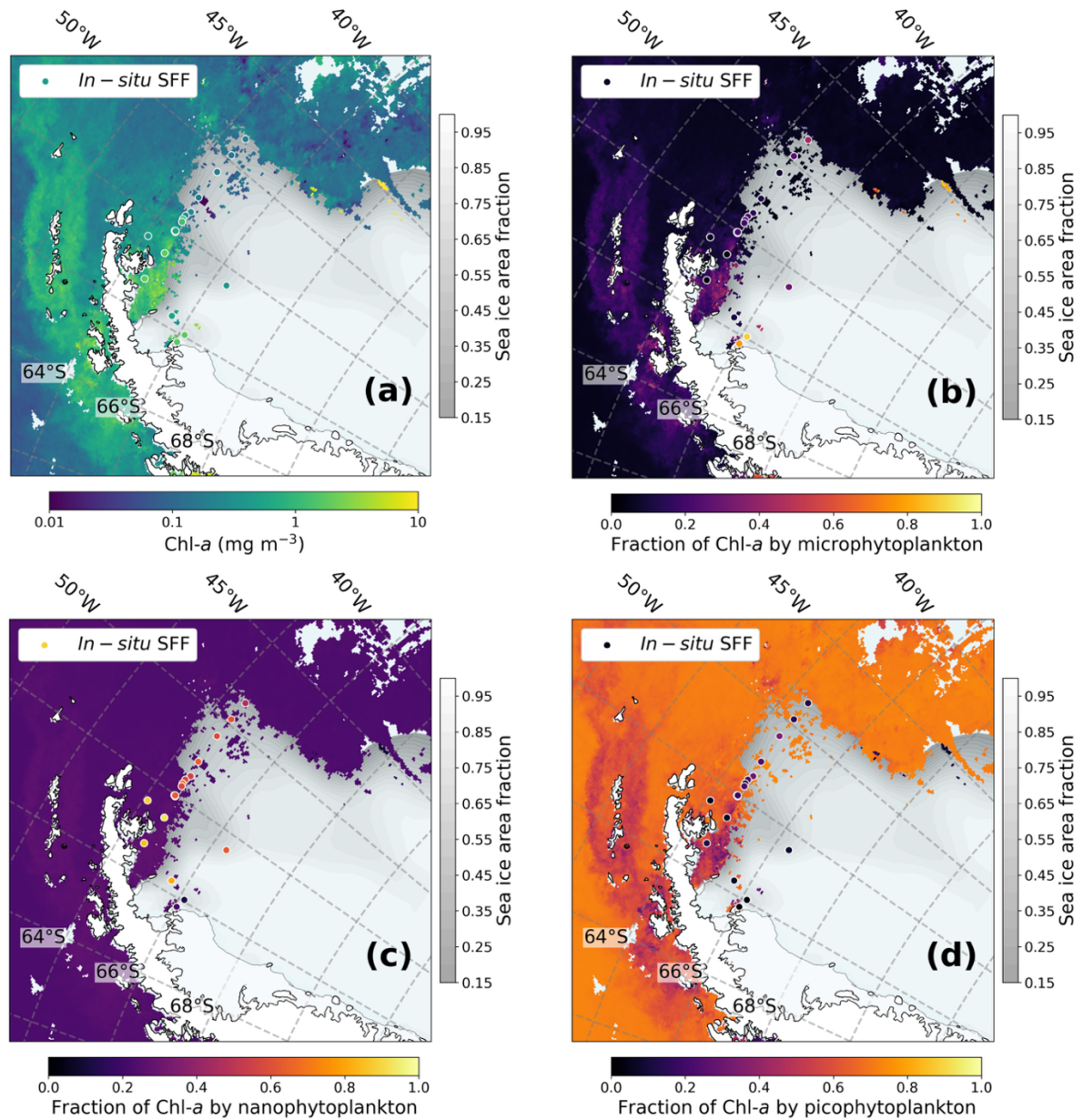


Figure R1: Satellite ocean colour (OC-CCI) and sea ice area fraction (NOAA/NSIDC) averages over the duration of the PICCOLO cruise (18 January 2024 to 2 March 2024) in the northwestern Weddell Sea. (a) Chl-a using the standard OC-CCI product, (b-d) the fraction of Chl-a by micro-, nano- and picophytoplankton respectively, using Eqs. 1-4 of the paper, and the AMT parameters in Table 2. *In-situ* SFF data from PICCOLO are overlain in white circles filled using the same colour scale as that used with the satellite imagery. An ice shelf layer is overlain onto the map, taken from the Scientific Committee on Antarctic Research (<https://www.add.scar.org/>), to illustrate the position of the Larsen and George VI ice shelves.

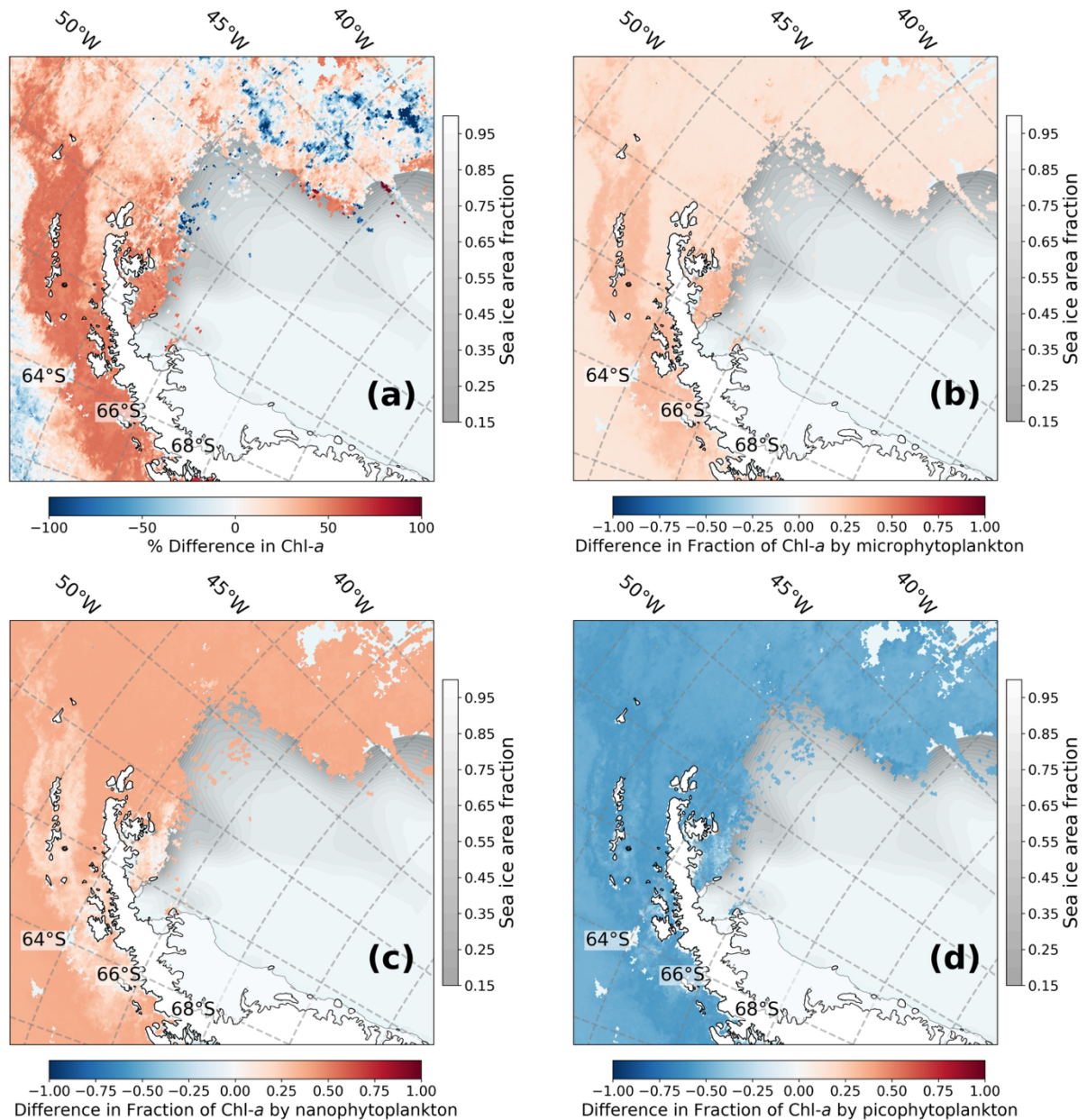


Figure R2: Differences between Figure 6 of the paper and Figure R1 above. (a) Median percentage difference in Chl-a between the standard product from OC-CCI (Figure R1a), and the regional algorithm of Ferreira et al. (2022) (Figure 6a of the paper). (b-d) absolute differences in the fraction of Chl-a by micro-, nano- and picophytoplankton respectively, using the PICCOLO parameters (Figure 6b-d of the paper), and the AMT parameters (Figure R1b-d above). An ice shelf layer is overlain onto the map, taken from the Scientific Committee on Antarctic Research (<https://www.add.scar.org/>), to illustrate the position of the Larsen and George VI ice shelves.

The methods and Table 1 indicate that samples from a range of depths were used in the analyses – perhaps it could be worth testing a re-calculation of the parameters in Table 2 using only near-surface data, for application to satellite OC data. Or at least testing the surface vs. full water column values and commenting on whether they are significantly different (i.e., do the PICCOLO curves in Figure 5g-i change noticeably if only near-surface samples are used?).

RESPONSE: An excellent point raised by the reviewer. We recalculated the parameters in Table 2 using only near-surface PICCOLO data (depth < 10 m, broadly representative of data within the 1st optical depth and the surface mixed-layer), and the values are provided in Table R1 below.

Table R1: Fitted parameters of the three-component model of Brewin et al. (2010) to all the PICCOLO data (as in Table 2 of the manuscript) and PICCOLO surface data (depth < 10 m)

Parameter	PICCOLO ALL	PICCOLO depth < 10 m
$C_{p,n}^m$	1.477 ± 0.291	1.637 ± 0.670
C_p^m	0.073 ± 0.010	0.098 ± 0.035
$D_{p,n}$	0.849 ± 0.029	0.920 ± 0.097
D_p	0.288 ± 0.025	0.230 ± 0.059
Number of samples	133	27

In all cases, we observed no significant differences in all model parameters, as indexed by overlapping standard deviation parameter uncertainties. Therefore, considering the comment raised, we will now add a footnote to Table 2 of the manuscript stating.

“Fits to near-surface PICCOLO data only (depth < 10 m, N = 27) showed no significant differences in model parameters, as indexed by overlapping standard deviation parameter uncertainties.”

Minor/Technical comments:

Figure 1 – Suggest including an inset map of location of the peninsula.

RESPONSE: Now added to revised manuscript, see modified Figure below (Figure R3)

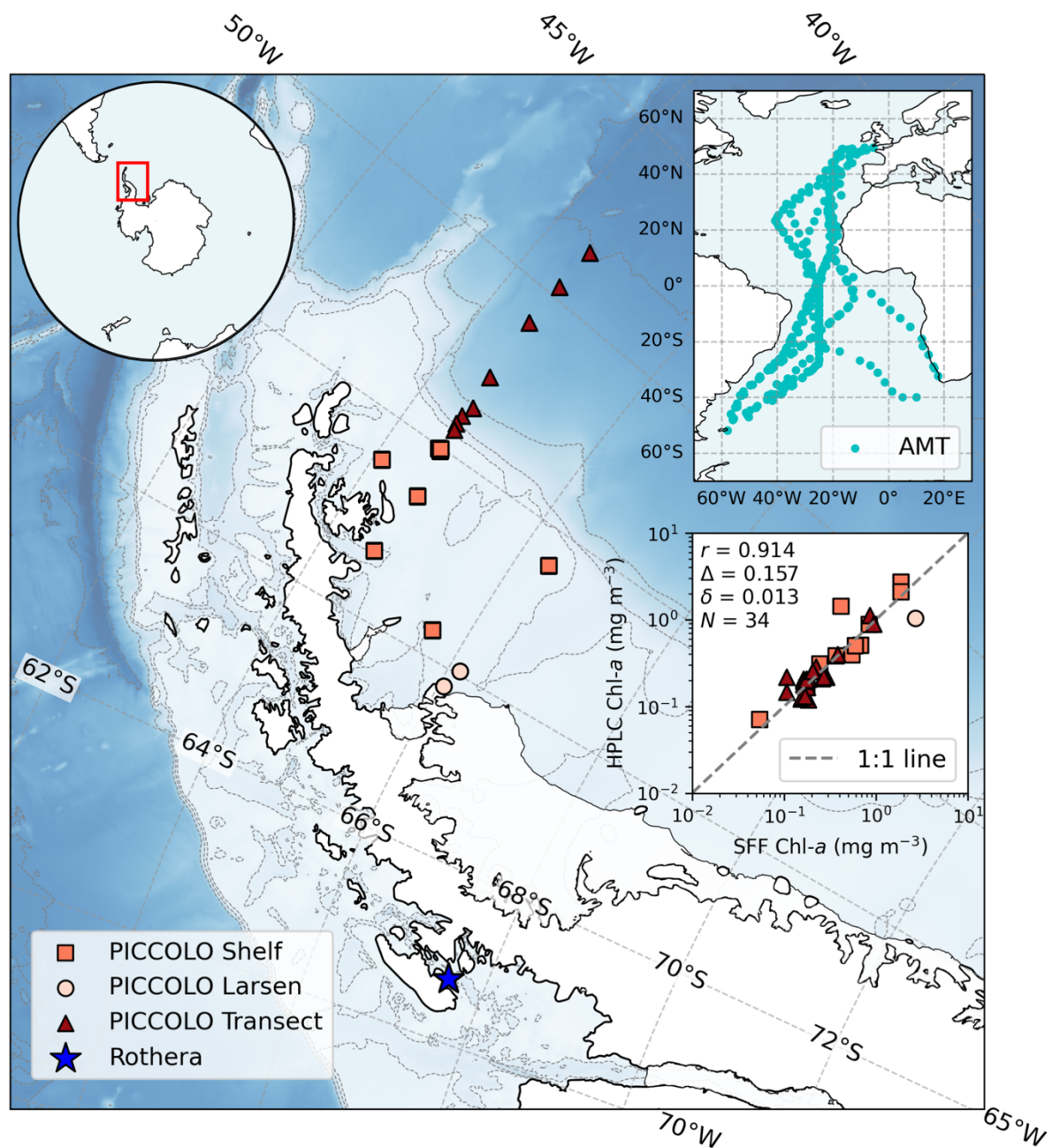


Figure R3. Revised Figure 1 of the paper, with inset map of location of the peninsula (top left).

L169 – should be ‘to derive’

RESPONSE: Now corrected.

L245 should be ‘a commonly-used’

RESPONSE: Now corrected.

L333 should be ‘picophytoplankton’

RESPONSE: Now corrected.

L275 Re: "Depth matching was performed using the nearest available sampling depth."
Perhaps include statistics on this - how far apart are the matches at most?

RESPONSE: The following sentence will now be added.

"For the 34 matchups, the median depth difference was 2.14 m (mean difference: 0.91 m), with a maximum difference of 26.83 m, corresponding to depths of 70.17 m (SFF) and 97.0 m (HPLC)."

References:

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