Response Reviewer 2

We would like to sincerely thank the reviewer for their time and valuable input. The suggested changes will surely enhance the quality of the paper.

1. Line 15-21: more references needed

More references have been added to these lines, including Sallee *et al.,* 2015*,* Ardyna *et al.,* 2017 and Hague & Vichi, 2018. References for missing data are Cole *et al.,* 2012 and Racault *et al.,* 2012.

2. Line 52: define what the marginal ice zone is

While we do offer a definition in the subsequent line we agree that this definition is not specific enough. The following clarification has been added to the revised manuscript:

“ *Note that we would define the MIZ here by dynamical considerations such as wave propagation (i.e. the MIZ may be defined as the region where wave attenuation is below a given threshold) and not a satellite ice concentration threshold (for example, see Squire et al., 2007; Meylan et al., 2014).* “

3. Line 71: define date range used rather than all available floats because this will always be changing

We thank the reviewer for raising this point and will update the manuscript. We have also included a table to the supplementary material which contains information (float ID, year, location) for all the floats analysed in the paper, which we show below.

Table 1. Table of all floats used in this study, including both the WMO ID and MBARI ID (for identifying floats on the SOCCOM website). The years of data which where used are shown, although there may be more available data at the time of reading. Mean locations for each float are also shown based on the time interval used for calculations.

WMO ID / MBARI ID	Years Sampled	Mean Latitude	Mean Longitude
5904768 / 0570SOOCN	2016	64.8°S	166.7°W
5904671 / 0507SOOCN	2016 2017 2018	62.3°S	82°E
5905636 / 12754SOOC	2018	67°S	149.4°W
5905078 / 12371SOOC	2017	66.6°S	124.4°W
5904858 / 12551SOOC	2017 2018	73.9°S	148.7°W
5904184 / 9091SOOCN	2014	61.4°S	147.4°W
5904469 / 9096SOOCN	2018	60.4°S	23.2°E
5904767 / 0568SOOCN	2016 2018	63.2°S	145.5°W
5904859 / 12549SOOC	2017 2018	70.2°S	104.3°W
5904857 / 12381SOOC	2017 2018	72.8°S	167.2°W
5905100 / 12361SOOC	2017 2018	65.2°S	166.3°E
5904860 / 12541SOOC	2017 2018	72.1°S	164.8°W
5905075 / 8501SOOCN	2017 2018	68.9°S	102.8°W
5904472 / 9275SOOCN	2015 2016 2017 2018	68.5°S	25.9°W
5904855 / 12559SOOC	2017 2018	68.3°S	83.8°W
5905077 / 12379SOOC	2017	65.7°S	107.1°W
5904468 / 9099SOOCN	2015 2016 2017 2018	65°S	2.3°E
5904471 / 9094SOOCN	2015 2016 2017 2018	65.7°S	4°E
5904397 / 9125SOOCN	2015 2016 2017 2018	61.2°S	2.4°W
5905080 / 12366SOOC	2017	65°S	117.7°W

4. In Methods: you need to discuss the sampling frequency of the floats as 10 days earlier on in the methods.

This has been added at line 72:

"*Analysis was done on data from 2014 - 2019, making use of chl-a, pressure, temperature, salinity and position data available at a 10-day frequency.* "

5. Line 92: ice melting already occurred ***or the float moved out of an ice covered region* (or the ice moved but may not have melted)**

This is a very good point, we have added these additional possibilities.

6. Line 173: list the standard nutrients rather than only saying 'all standard nutrients' + Line 174: citation needed or source for the nutrient concentrations used.

All nutrients are now added at line 173, along with citations for concentrations:

" *In terms of nutrients, phosphate, nitrate and ammonium are included, as well as silicate and iron. Initial nutrient conditions where chosen to be representative of the Southern Ocean south of ~60°S, with non-limiting concentrations of nitrate (31.8 mmol/m^3), phosphate (2 mmol/m^3) and silicate (40 mmol/m^3) (Sarmiento and Gruber, 2006). An initial dissolved iron concentration of 0.3 µmol/m^3 (Tagliabue et al., 2014) is applied to all experiments, which gave the most realistic magnitude of summer growth when compared to float data.* "

7. Line 179: How was MLD defined?

This is an oversight on our part, thank you for pointing it out. The MLD is defined as the depth at which the Brunt-Viasala frequency is maximal in the water column, which is mentioned later in the text under "Melt Detection." We have added text pointing the reader to this definition at the first mention of MLD at line 179.

8. Line 199: Is it more correct to say Bio-Argo? Or is it BGC-Argo? Used both ways in manuscript.

We will change all references to BGC-ARGO.

9. Figure 5/6: Captions should be more stand alone and not just refer to the text. I recommend providing a little more detail in the captions.

Captions have been updated in the revised manuscript as follows:

"*Figure 5: Distribution of the difference in timing (in days) between growth initiation (GI) and melt onset (for all floats sampling under ice). GI is defined as the point at which the time derivative of mean mixed layer chl-a exceeds the median time derivative (computed for the growth period).*

Negative values in the distribution indicate that GI has occurred prior to the detected melt onset. Curved lines represent the probability density functions for several values of the assumed cooling threshold (rc) in the upper ~20 m of the water column. This value represents an assumed decrease in temperature over the upper ~20 m, which is required to delineate under ice from open ocean profiles (since floats do not sample the upper ~20 m in winter, they do not sample water below the freezing point). "

" *Figure 6: Satellite sea ice concentration (SIC) versus ARGO-float chl-a for the region R75. Shaded regions around each line represent both the spatial and temporal variability present in each dataset.That is, each bold line plots the mean value of 5 time series which are associated with a specific melt event. Events are separated in space and time; in this particular case 2017 and 2018 were sampled by 3 floats (see table 1), which resulted in 5 time series (2 each, with one of the floats only sampling in 2017). The red star represents the mean value of GI.* "

10. Line 310: In the Briggs 2017 study a respiration signal was observed in oxygen and DIC inventories during the under ice period but switched to production prior to the estimated ice edge (see figures 4 and 6). There is no clear disagreement between these two studies just a different time-frame focus.

We thank the reviewer for bringing this point to our attention and agree that the studies are focussed on different periods. We would also add that Briggs *et al.* 2017 is also more focussed on blooms (i.e. high chl-a concentration, as they compare years with and without a bloom in their Figure 3), while our study is more focussed on growth in general (i.e. relative changes in chl-a as opposed to absolute magnitudes). The manuscript has been updated to reflect these points, with the following statement added within the paragraph starting at line 310:

"*Thus, the seemingly contradictory conclusions of our results is due to differences in which period of season the analysis is focussed on, with Briggs et al. (2017) focussing on earlier periods of the year when the respiration signal is dominant, and the work presented here focussing on the early spring period when respiration switches to production.*"

11. Line 312: Satellite data was also used in this study to estimate ice cover Discussion: Have you compared the MLD at the time of GI for each of the floats?

At lines 220-221 we state that the average stratification depth (our metric of MLD) at GI is 129 m. We have now added that the standard deviation is 51 m, highlighting fairly substantial variability present in the data set. In addition, we have added a figure showing the relationship between stratification depth and GI to the supplementary material, which we show below. We have added to the manuscript at line 221 that there is no correlation between the extent of vertical mixing (i.e. stratification depth) and GI, as well as commented on the range of values found for the stratification depth.

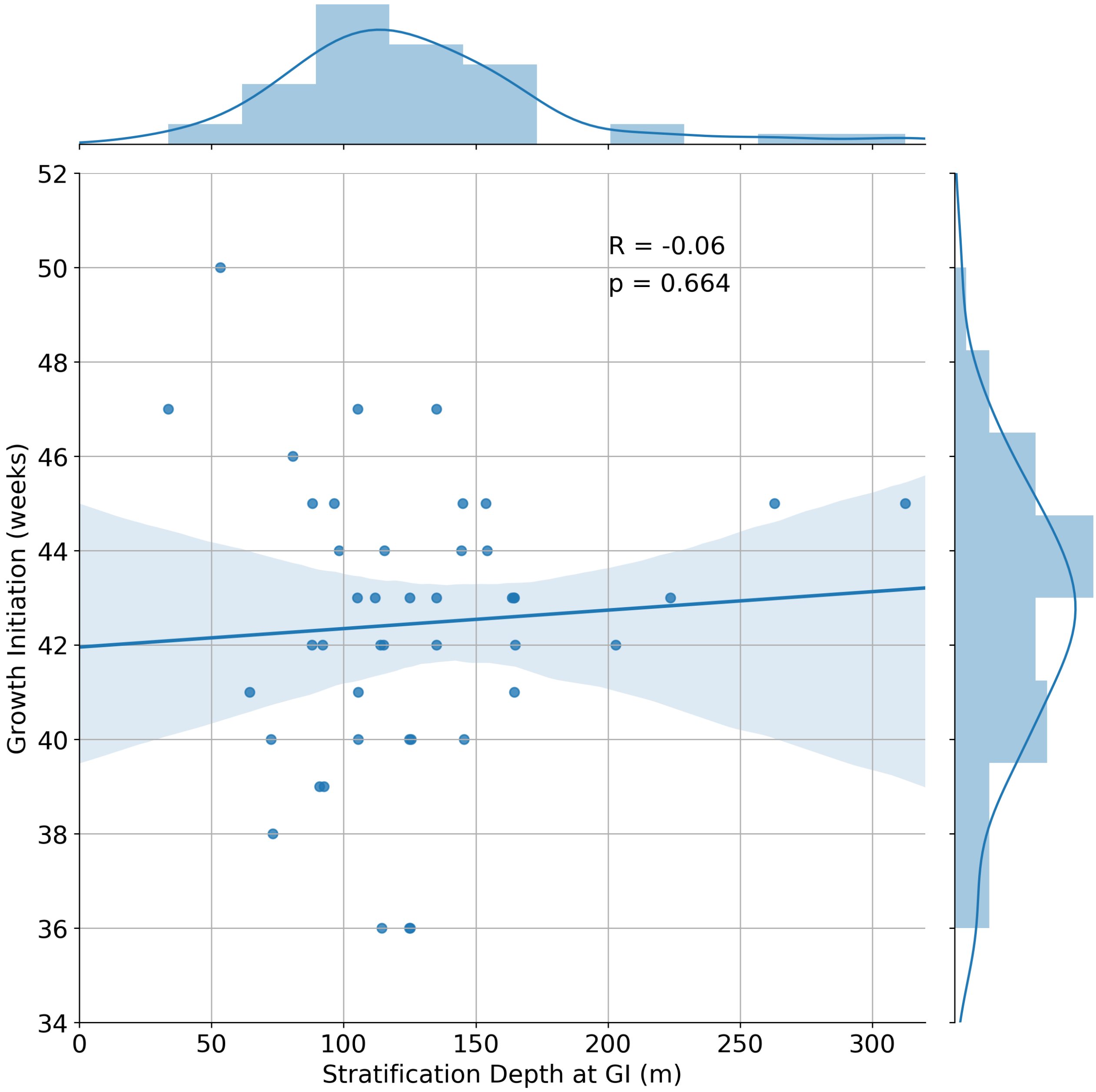

Figure 1: Stratification Depth (Nd) at the timing of GI plotted against GI for each of the 42 melt events detected. Overlain in blue is the linear regression with the 95% confidence intervals for 1000 bootstrapped resamples shaded in light blue. Histograms and PDFs of each variable are shown along the edge of the axes.

Technical Corrections

12. Abstract: 0D model? Did you mean 0.5D as later referred to in the manuscript?

Yes, we were referring to the 0.5D model presented in the study. We felt that specifying 0.5D in the abstract would lead to potential confusion, since most readers would be familiar with 0D models but not 0.5D. Therefore, we have updated the abstract to read “box model with varying vertical depth” as follows:

“This led to the development of several box model experiments (with varying vertical depth) in which we sought to investigate the mechanisms responsible for such early growth.”

13. Line 142: change shown to show

This has been changed.

14. Table 2: inconsistent letter case

Letter case is consistent now.

15. All figures: the font is very small. I would recommend increasing all figure text font.

We have increased the font of all figures.

16. Figure 7: I recommend plotting all four subplots with same size axes. Only the bottom right plot has a larger x-axis.

We assume the reviewer is referring to the y-axis, as the x-axes are all the same size. We have updated the figure as suggested.

17. Line 289: Add 'In' to start of sentence 'Figures 5 and 6…'

Typo corrected.

18. Line 370: Needs commas

We would argue that adding commas changes the meaning of the sentence in a way that is not intended. However, we agree that the sentence needs to be changed to be more understandable and therefore suggest the following:

"The presence of even a tiny amount of light may be expected to induce acclimation in primary producers (that are adapted to low light), thereby explaining why model configurations which take this into account produce a more realistic phenology. "

References

Ardyna, M., Claustre, H., D'Ortenzio, F., van Dijken, G., Arrigo, K. R., D'Ovidio, F., Gentili, B., and Sallée, J.B.: Delineating environmental control of phytoplankton biomass and phenology in the Southern Ocean, Geophysical Research Letters, 44, 5016–5024, https://doi.org/10.1002/2016gl072428, 2017.

Cole, H., Henson, S., Martin, A., and Yool, A.: Mind the gap: The impact of missing data on the calculation of phytoplankton phenology metrics, Journal of Geophysical Research: Oceans, 117, https://doi.org/10.1029/2012JC008249, https://agupubs.onlinelibrary.wiley.com/ doi/abs/10.1029/2012JC008249, 2012.

Hague, M. and Vichi, M.: A Link Between CMIP5 Phytoplankton Phenology and Sea Ice in the Atlantic Southern Ocean, Geophysical Research Letters, 45, https://doi.org/10.1029/2018GL078061, 2018.

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Sallée, J.-B., Llort, J., Tagliabue, A., and Levy, M.: Characterization of distinct bloom phenology regimes in the Southern Ocean, ICES Journal of Marine Science, 72, 1985 – 1998, https://doi.org/10.1038/278097a0, 2015.