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# Interactive comment on "A latitudinally-banded phytoplankton response to 21st century climate change in the Southern Ocean across the CMIP5 model suite" *by* S. Leung et al.

**Anonymous Referee #1**

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Review of Leung et al. "A latitudinally-banded phytoplankton response to 21st century climate change in the Southern Ocean across the CMIP5 model suite"

This manuscript uses output from 17 Earth system models using historical and future scenarios to investigate the changes in Southern Ocean phytoplankton distributions and potential drivers. I found the manuscript provided interesting perspectives on how and why phytoplankton productivity may change in the SO with future climate change. Further, the manuscript was well-written with (mostly) clear figures. I recommend publication after addressing the following comments.

Page 8161: Is all of the output used annual mean values only? Or is monthly data used

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too? Somewhere it would be good to include a list of the CMIP5 variable names used (e.g. intpp, nit etc.). Also, do all models include all variables examined? I guess not, but the information wasn't easy to extract.

Page 8163, line 1-2: presumably this should be "positive or negative change" – it's the sign of the trend that's important for the bootstrap analysis I think?

Page 8163, line 25-27: just because 2 models show the same sign of the trend in PP or PB doesn't mean that you are comparing the same water masses. I think this is a fallacious argument and the authors would do better to just use the 'increasing the signal to noise ratio' to justify this decision.

Section 2.6: I found this confusing. Why not just use the control run of the models to define interannual variability without climate change effects – that after all is exactly what the control run represents. I found the mathematical gymnastics in this section confusing and perhaps unnecessary – surely the "control and climate change time series" of the section title are the control and RCP8.5 runs of the models?

Page 8165, lines 5-11: In the calculation of trends (here particularly because monthly data is used, but also elsewhere with annual data), are the effects of autocorrelation accounted for? Calculating a trend on monthly data without accounting for autocorrelation will result in spurious correlations and too-small p-values.

Page 8168 – discussion of sea ice reduction. A figure or reference to published work is needed here to show the extent of sea ice retreat.

Page 8170, lines 14-19: the authors state that within each band the drivers of pp response are the same in all-model mean as in individual models – I would say except in the 50-65S band where there is some model disagreement on drivers.

Page 8171, lines 1-5: unmasked comparisons should be shown for selected correlations (similar to Figs 2 + 3), rather than the unselected ones, so that the reader can more easily assess the impact of using the masking. Also, a table with the slopes

calculated in Figures 2 and 3 would make comparison easier.

Page 8171, lines 24-29: Although the authors conclude that the same mechanisms act on timescales of interannual to centennial, in reality on long time scales phytoplankton adaptation could alter the driver-response relationship which they observe at the interannual scale. This should be included in the discussion.

Page 8172, lines 22...Page 8173, line 17: I think this section should refer to figure 4? (not figure 3) Worth noting that although various relationships are discussed, only the relationship with max yearly winter nitrate is significant. The boxes are also artificially chosen to draw the eye in some cases, with lots of points falling outside the boxes, e.g. green and purple on Fig 4c.

Page 8173, lines 20.. – what is it in the model formulation that makes a particular model's pp more or less sensitive to iron?

Page 8174, lines 25-29: the summertime MLD decreases, but wintertime iron increases. I assume that the atmospheric deposition of iron does not have an increasing trend in the models? So this implies that wintertime mixing must be deeper to result in increased winter time iron. In turn, this suggests that there will be a more pronounced seasonal cycle in MLD. What mechanism might cause this?

Page 8179, lines 15-24: surely the observations should be compared to the same period in the historical runs, not to the full future runs? Also, I think the satellite-derived trends are calculated on monthly data, but model output is annual? So not directly comparable. (Also see earlier comment about accounting for autocorrelation).

Page 8179, lies 28-29: I disagree that the comparison with observed data "suggests that the effects of climate change on SO phytoplankton may have already become detectable". The authors have only shown that there may be some similar sign/pattern of trends and possibly some consistent mechanisms in 2 time series which have substantial difference (as in above comment). For detection to occur, much more rigorous

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analysis than this is required.

Figure 1: the latitudes need to be marked on one of the figures so that it's easier for the reader to relate the text referring to various latitudinal bands to the figures.

Figure 2: It's really hard to distinguish the different symbols here, particularly the grey ones.

Figure 3: are these best fit lines statistically significant?

Figure 4: How were these potential drivers chosen? PPmax is used throughout as a metric – if the authors are trying to assess overall productivity, the annual total (integrated) PP would be a much better measure. Also, the authors are then comparing a single event (the max PP) to an annual average, e.g. cloud fraction. Again, it be more consistent to compare annual average cloud fraction to annual average or total PP.

Figure 5: For band 50-65S, PP is reported as having 41% decrease, but by eyeball looks like mostly increasing. Also, for this band and for 40-50S, only half of the models agree on the sign of the trend for PB, which should be noted.

Figure S11: Add a colour legend to this figure to stop the reader having to flick back and forth.

Figure S12: What does the star indicate in the bottom left plot? (and for Fig S13-15 too).

Figure S16: W is not reported in some sub-plots, e.g. c,d,i

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