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Interactive comment on "Sensitivity of ocean biogeochemistry to the iron supply from the Antarctic ice sheet explored with a biogeochemical model" *by* Renaud Person et al.

Anonymous Referee #3

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This paper presents a study evaluating the impact of Fe supply from Antarctic ice shelves and icebergs on productivity/chlorophyll in the Southern Ocean. It presents a thorough examination of the uncertainties associated with the fertilisation capacity of this input and highlights remaining differences between the observations and model results even when these Fe sources are included. The authors highlight particular areas where existing models can be improved, or futher in-situ observations are required. With some improvements, I believe this paper is a valuable addition to the field.

I am reviewing this paper with shallow knowledge of the biogeochemistry and will be focusing on iceberg and ice shelf melt.

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Larger corrections

It was not clear whether the Fe supply is injected at a particular layer, and no further dynamics apply, or whether once the Fe is added, those waters are able to mix (as is likely to happen associated with the buoyancy injection from meltwater)? This applies throughout the paper, but in particular on page 13 (line 30-35) where you discuss the possible cause of differences between your primary production are that found in Laufkötter et al (2018).

Some further discussion of this, and the general background associated with the meltwater pump would be valuable. Recent papers have shown the effect of this in Antarctic waters (St-Laurent et al., 2017, 2019: Cape et al., 2019) and in your discussion you only refer to this process associated with Greenland glaciers (pg 15, line 21).

Similar to the meltwater pump model for ice shelves, are similar processes considered for iceberg melt? For iceberg melt occurring at depth, mixing with surrounding waters may result in upwelling of nutrient-rich waters, rather than the iceberg Fe-source remaining trapped below the ML.

Smaller corrections

Abstract: Line 12-13: The comment that seasonal variations have regional impacts that are then “almost negligible” is slightly confusing. May be better to re-word this sentence?

Pg2: Some other references to consider in this section are Cape et al (2019) (ice shelf meltwater pump), Biddle et al (2015), in-situ observations of productivity from iceberg melt,

Line 17: I’m not sure you’ve defined AIS yet. Be very clear about the differences between AIS (I assume Antarctic Ice Sheet?), ice shelves and icebergs.

Line 27: “fueling” in what way? Is the Fe used, or is it just supplied? Line 34: remove “the” before “Prydz Bay”

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Discussion paper

Pg 3, line 18: I would read “along the water column” as along the iceberg tracks (spatial/horizontal). Is this what you mean, or do you mean the vertical distribution?

Pg 4, line 10: For those unfamiliar with the model, a brief description here of how the freshwater fluxes are added would be helpful. Are the ice cavities simulated? Or is it a vertical wall in the model that freshwater/Fe is added through? In the latter case, what does “between the base and the grounding line of the ice shelves” then refer to – freshwater fluxes are equally added between the depth of the ice shelf (say 400 m) and the seabed? In this situation, many recent papers have shown that the strongest outflow is at the base of the ice shelf and diminishes with depth, in addition to buoyant upwelling to the surface (Naveira Garabato et al., 2017; Nakayama et al., 2014). Again, this is relevant to the meltwater pump.

Pg 6, line 24: “as well as in the Ross Sea until the Amundsen Sea” – I’m not sure what you mean by this? The Indian and Pacific sectors include these coasts? (See comment in figures about specifying what region you are referring to).

Pg7, line 9-10: I am not sure what you mean by “Furthermore, in winter. . .”.

Pg 10, Lines 14-18: I think the meltwater pump should be included here – the ice shelf Fe is not just injected deeper than the mixed layer. Line 33: “The mains” → “The main”

Pg 11, Line 11: remove “the” in front of Bouvet. Line 15: remove “by” in front of “∼1.3. . .”

Pg 13, Line 30-35: This deserves more discussion about why there are differences between the models with similar Fe fluxes. Are there physical differences in the models in how they treat mixing of meltwater/depth of meltwater input?

Pg 15, Line 20-23: This seems quite likely (e.g. Cape et al, 2019) – see earlier general comment. Line 34: “we did not explore”

Figures – I would like the labels on the maps for longitudes to be slightly larger, and to be consistent with the direction/order of labelling panels. You also refer to the different

sectors a lot (e.g. Indian-Pacific sector) – is it possible to mark the boundaries of these sectors, perhaps just on the first figure?

Figure 5 – what is the colorbar for this figure?

Figure 8 has an incorrect caption (it is identical to Figure 7).

References:

Biddle, L. C., J. Kaiser, K. J. Heywood, A. F. Thompson, and A. Jenkins (2015). Ocean glider observations of icebergâĂŘenhanced biological production in the northwestern Weddell Sea. Geophys. Res. Lett., 42, doi:10.1002/2014GL062850.

Cape, M. R., Vernet, M., Pettit, E. C., Wellner, J., Truffer, M., Akie, G., Domack, E., Leventer, A., Smith, C. R. and Huber, B. A (2019). Circumpolar Deep Water Impacts Glacial Meltwater Export and Coastal Biogeochemical Cycling Along the West Antarctic Peninsula , Front. Mar. Sci. , 6, 144 [online] 10.3389/fmars.2019.00144.

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St-Laurent, P., Yager, P. L., Sherrell, R. M., Stammerjohn, S. E. and Dinniman, M. S.: Pathways and supply of dissolved iron in the Amundsen Sea (Antarctica) (2017). J. Geophys. Res. Ocean., doi:10.1002/2017JC013162.

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