Dear Reviewer & Editor,

We thank the reviewer for her/his supportive and constructive comments on our manuscript. Please see below, in blue, our detailed responses to the comments.

I commend the authors for the scale and complexity of this work, which reflects an incredible amount of work from start to finish. The overall aim of this project, to evaluate palaeoceanographic conditions (winter sea ice and SST) during MIS 5e, in comparison to average modern conditions, is well conceived and of broad scale interest. This time period presents an appropriate test case for comparison, in terms of understanding/ anticipating near future conditions of the Southern Ocean, and the ramifications on an array of variables, ranging from changes in bottom water formation to ecosystem scale changes. For this reason, I found the introduction and conclusion to be especially useful and aimed toward wide audience, including those with less specific interest in the details of the diatom work. The data are well-illustrated and clear, easy to follow; thanks for the common x-axis scaling.

Specific comments:

1. I realize that the authors are limited by the cores available, that are suitable for this study – core length and time scale covered, resolution, and diatom preservation. In terms of future work, identification of key missing pieces might be helpful, with a very limited ability to truly evaluate the Indian Ocean sector of the Southern Ocean, with no cores reflecting almost this entire sector, which is about half of the studied area. The two cores analyzed reflect only the edge of this sector and are relatively high latitude. Given that, it is difficult to make substantive conclusions about this sector. This is just an observation, not a criticism. However, it might be a good idea to re-frame the term “Indian Ocean sector” which really isn’t well-addressed geographically.

We agree that the use of “Indian Ocean sector” was misleading given the locations of the cores. We reiterate that none of the published cores from the Indian & west Pacific sectors of the Southern Ocean (Crosta et al. 2004, Ferry et al. 2015, Nair et al. 2019, Chadwick et al. 2020, Ghadi et al. 2020, Jones et al. 2021, *in review*) are located far enough south to record sea ice during the LIG, which is the focus of this present study. As the modern sea-ice edge lies at around 62 ^{o}S in the eastern Indian sector, only cores proximal to the Antarctic continent allow to infer WSI during the LIG. Obviously, similar studies in other regions off East Antarctica must be conducted to provide a basin-wide view of sea-ice conditions in the Indian sector during the LIG. For these reasons, we will use “East Indian Ocean sector” in the revised manuscript to account for the specific location of our cores.

2. I appreciate the reluctance to overinterpret, especially when the environmental controls on some species, or species groups, is more complicated than temperature and/or sea ice. The authors allude to this for example, in noting the unusual abundance of Fragilariopsis separanda, for example, on page 9-10 (lines 193-203). This impacts their statistical analysis and interpretation, yet clearly reflects something different. Thanks to the authors for pointing this out – yet one more species to re-evaluate. And despite the very common use of F. curta + F. cylindrus as a sea ice indicator, their differing distribution in the modern ocean suggests that the story is more complex. How confident are the authors in suggesting that F. cylindrus is associated with sea ice meltwater? I suggest adding reference to several older papers, that might strengthen this association:

Kang, S.-H., Fryxell, G.A., 1992, Fragilariopsis cylindrus (Grunow) Krieger: The most

abundant diatom in water column assemblages of Antarctic marginal ice-edge zones, Polar Biology, 12, 6-7, 609-627.

Kang, S.-H., Fryxell, G.A., 1993, Phytoplankton in the Weddell Sea, Antarctica: composition, abundance and distribution in water-column assemblages of the marginal ice-edge zone during austral autumn, Marine Biology, 116, 335-352.

Kang, S-H., Fryxell, G.A., Roelke, D.L., 1993, Fragilariopsis cylindrus compared with other species of the diatom family Bacillariaceae in Antarctic marginal ice edge zones, Nova Hedwigia, 106, 335-352.

We will add these additional references along with a couple of sentences on *F. cylindrus* ecology to strengthen our argument:

"The peak in FCC abundance in core TPC287 at 126 ± 2.6 ka is primarily a peak in the abundance of F. cylindrus *(Chadwick & Allen 2021).* F. cylindrus *dominates modern diatom assemblages in both ice-covered and open ocean locations in the marginal sea-ice zone (Kang & Fryxell 1992, 1993, Kang et al. 1993). The occurrence of high modern* F. cylindrus *abundances in locations not covered by sea ice at any point during that season indicates that this species is not purely associated with sea-ice extent but also affiliated with sea-ice melt and strong surface stratification (Kang & Fryxell 1993, Cremer et al. 2003, von Quillfeldt 2004). The peak in* F. cylindrus *abundances at 126 ± 2.6 ka in core TPC287, separate from any notable increase in* F. curta *abundance, therefore supports an increased glacial meltwater signal at this time.*

3. Table 2: are the +/- values overly precise, especially given bioturbation? In lines 140-142, the age uncertainty is widened, given the thickness of the sample interval (which pretty narrow, only 0.5 cm).

We will amend the age uncertainties to a single decimal place, as is used throughout the rest of the manuscript.

4. How does this paper compare to the Chadwick et al. paper that is in review? Without seeing both it is difficult to evaluate the unique contributions of each.

The Chadwick et al. paper in review compares diatom abundances in MIS 5e sediments to the abundances in seafloor surface sediments and does not include any quantitative transfer function reconstructions of sea ice or SSTs. We therefore believe that the present study gives much more information on sea-ice conditions at the LIG, and the potential drivers, than the Chadwick et al. paper in review in Marine Micropaleontology.

5. Line 275 – Interesting comment regarding the abundance of Chaetoceros resting spores in TPC290, such that the analog is closer to modern day Antarctic Peninsula. Lines 302-309, another reference to higher Chaetoceros, this time in core ELT17-9. I wonder if this might be associated with earlier timing of sea ice breakout in the spring, a longer open water season with a stronger spring bloom signal? Or upwelling? Or both?

We agree that these are possible additional explanations for the higher *Chaetoceros* rs. abundances and will expand the discussion to include these alternative causes, especially with regard to the Pacific sector core ELT17-9.

6. Lines 383-391, discussion of changing ecosystem due to sea ice changes in the Weddell Sea sector: Consider references to:

Moline et al. 2004, Alteration of the food web along the Antarctic Peninsula in response to a warming trend. Global Change Biology. 10. 1973-1980 and Mendes et al., 2018, New insights on the dominance of cryptophytes in Antarctic coastal waters: A case study in Gerlache Strait. DSR II, 149, 161-170.

I realize that both these papers are from the western side of the Antarctic Peninsula but note the impact of meltwater and a warming ocean on primary producers and impacts that cascade through the food web.

We will expand the discussion on ecosystem impacts to further detail the possibly effects of warming and meltwater release on the wider food web.

7. Line 395 - remove parenthesis since this is an important consideration. In general, if it's important enough to be stated, no parentheses necessary.

We will remove the parentheses.

Rebuttal references:

Chadwick M. & Allen C.S. 2021. Marine Isotope Stage 5e diatom assemblages in marine sediment core TPC287 (-60.31 ºN, -36.65 ºE, Cruise JR48) *UK Polar Data Centre, Natural Environment Research Council, UK Research & Innovation*.

Chadwick M., Allen C.S., Sime L.C. & Hillenbrand C.D. 2020. Analysing the timing of peak warming and minimum winter sea-ice extent in the Southern Ocean during MIS 5e. *Quaternary Science Reviews*, **229**: 106134.

Cremer H., Roberts D., McMinn A., Gore D. & Melles M. 2003. The Holocene Diatom Flora of Marine Bays in the Windmill Islands, East Antarctica. *Botanica Marina*, **46** (1): 82-106.

Crosta X., Sturm A., Armand L. & Pichon J.-J. 2004. Late Quaternary sea ice history in the Indian sector of the Southern Ocean as recorded by diatom assemblages. *Marine Micropaleontology*, **50** (3-4): 209-223.

Ferry A.J., Crosta X., Quilty P.G., Fink D., Howard W. & Armand L.K. 2015. First records of winter sea ice concentration in the southwest Pacific sector of the Southern Ocean. *Paleoceanography*, **30** (11): 1525-1539.

Ghadi P., Nair A., Crosta X., Mohan R., Manoj M.C. & Meloth T. 2020. Antarctic sea-ice and palaeoproductivity variation over the last 156,000 years in the Indian sector of Southern Ocean. *Marine Micropaleontology*, **160**: 101894.

Jones J., Kohfeld K., Bostock H., Crosta X., Liston M., Dunbar G., Chase Z., Leventer A., Anderson H. & Jacobsen G. 2021, *in review*. Sea Ice Changes in the Southwest Pacific Sector of the Southern Ocean During the Last 140,000 Years. *Climate of the Past Discussions [preprint]*.

Kang S.-H. & Fryxell G.A. 1992. *Fragilariopsis cylindrus* (Grunow) Krieger: The most abundant diatom in water column assemblages of Antarctic marginal ice-edge zones *Polar Biology*, **12** (6-7): 609-627.

Kang S.-H. & Fryxell G.A. 1993. Phytoplankton in the Weddell Sea, Antarctica: composition, abundance and distribution in water-column assemblages of the marginal ice-edge zone during austral autumn. *Marine Biology*, **116**: 335-348.

Kang S.-H., Fryxell G.A. & Roelke D.L. 1993. *Fragilariopsis cylindrus* compared with other species of the diatom family Bacillariaceae in Antarctic marginal ice-edge zones. *Nova Hedwigia*, **106**: 335-352.

Nair A., Mohan R., Crosta X., Manoj M.C., Thamban M. & Marieu V. 2019. Southern Ocean sea ice and frontal changes during the Late Quaternary and their linkages to Asian summer monsoon. *Quaternary Science Reviews*, **213**: 93-104.

von Quillfeldt C. 2004. The diatom *Fragilariopsis cylindrus* and its potential as an indicator species for cold water rather than for sea ice. *Vie et Milieu / Life & Environment*, **54** (2-3): 137-143.