Rebuttal to Anonymous Referee #2 by Bijl et al.

This paper presents environmental interpretations of a new dinoflagellate cyst dataset from Oligocene and Miocene sediments from a drill core collected off the Wilkes Land coast. The environmental interpretations are partly underpinned by published studies on the distribution of dinoflagellate cysts in modern sea floor sediments. In particular, assemblages are identified that are interpreted to correlate with sea ice. The authors use these assemblages to conclude that sea ice was more prevelant during the earliest Miocene [**We assume R2 means Oligocene here**], and also following the Middle Miocene Climatic Optimum. They also observe that assemblages representative of interglacial conditions are similar to assemblages of modern temperate oligotrophic waters, and thus infer that this reflects a migration of the polar frontal system to the south of the drill site. This is an interesting paper, and the dataset is important. It will be of interest to the research community.

I have four main comments on the approach used and the conclusions drawn

(1) The authors note that in modern settings, Selenopemphix antarctica is dominant in 'proximal sea ice settings south of the Antarctic Polar Front' (but also that these modern samples from Antarctic waters have a range of 10-90% S. antarctica). The authors then infer that the intervals in the Wilkes Land core containing the highest relative abundance of S. antarctica represent depositional environments proximal to sea ice. However, S. antarctica is never above _15% in any of the samples reported in this study (Figure 7): this taxon is not dominant. **[Fig. 7 only reports the mean and 1sd of the data. The maximum abundance of *S. antarctica* is 39%. We will make the raw data available in a revised version]** For context, samples with concentrations of up to 20% S. antarctica occur in modern Southern Ocean samples as far north as the Subtropical Front (e.g. Zonneveld et al. 2013, doi.org/10.1016/j.revpalbo.2012.08.003). Even if high abundance (>80%) of S. antarctica were indicative of sea ice (which is itself not clearly demonstrated, partly given the poor modern correlation between the polar front and sea ice extent, and partly due to the very sparse coverage of modern samples south of the polar front), that high abundance is not the case in the samples reported in this paper. The modern analogue approach used by the authors to infer the presence of sea ice is inconclusive in this instance: the data presented could be just as easily used to infer a complete lack of sea ice for the duration of the record, as sea ice variability. **We agree with the reviewer that the complete compilation by Prebble et al. (2013) leaves ambiguity about the reliability of *S. antarctica* as sea ice indicator, and that the absence of this species should be taken as absence of sea. Sites south of the subtropical front with lower abundances of *S. antarctica* are all close to the polar front itself, and are in regions with lower palaeobathymetry (e.g., Kerguelen and in the South Atlantic). This causes highly variable distribution patterns around such bathymetric highs (see, e.g., Armand et al., 2008). Meanwhile, on the Antarctic continental shelf proper, where admittedly few published data is available in the Prebble et al. (2013) compilation, *Selenopemphix antarctica* does dominate the palynomorph assemblages in all sites available. The dominance of *S. antarctica* in assemblages can be found in the Wilkes Land margin itself (Site U1357; Hartman et al., in prep-a), in the Ross Sea (Hartman et al., in prep-b), Prydz Bay (Storkey, 2006), in the Indian Ocean (Marret and De Vernal, 1997) and in the Weddell Sea (Esper and Zonneveld, 2002; Harland and Pudsey, 1999). We echo the studies from Houben et al. (2013) and Sangiorgi et al. (2018), which elaborately discus the potential of *S. antarctica* as sea-ice indicator and its ecological meaning. We understand that the explanation in our manuscript falls short in providing the reader sufficient information on this matter. In a new version of the manuscript, we will support our inference of *S. antarctica* as sea ice indicator (and its absence as indicator of longer-than-today open water season) more elaborately than we did so far.**

(2) The authors conclude they demonstrate 'variability on glacial/interglacial timescales'. This is possibly true, but it has not been illustrated in a convincing way. The key to their interpretation, I think, is figures 6 and 7, where the relative abundance of different dinoflagellate cysts are illustrated for different lithologies. However, there is no evidence presented in this paper that these lithologies are deposited under different glacial conditions. They instead refer to Salabarnada et al.

(in review submitted to CPD). Salabarnada et al. describe a glacial 'Facies 1', and an interglacial 'Facies 2'. Although the present authors rely on the cyclo-stratigraphy of Salabarnada et al. for their glacial-interglacial interpretation, they choose (confusingly) to apply a different lithological scheme in the present paper. Thus, in Table 2, the authors assign 'Silty claystones and sandstones' to (glacial) Facies 1 of Salabarnada et al., and 'carbonated rich and pelagic clay lithologies to (interglacial) Facies 2. Notwithstanding this, the dinoflagellate cyst assemblages shown in Figures 6 and 7 do not vary in a consistent way between either the glacial and interglacial facies described by Salabarnada et al., or by the glacial and interglacial lithologies assigned by the authors (line 300-302). The different lithologies do contain different dinoflagellate cyst assemblages, but these differences do not appear to fall along the glacial/interglacial divisions proposed by either Salabarnada et al. or the authors.

We agree that the different presentation of the lithologic facies in our ms and that of Salabarnada et al may generate confusion. In a new version of the manuscript, we will make this consistent. In anticipation of this review, we have already revisited the Miocene lithology, made a detailed description and integrated the facies into the other lithologies described in Salabarnada et al. This did not lead to any different conclusions than those already made, namely a higher relative abundance of protoperidinioid dinocysts in glacial deposits, and more gonyaulacoid dinocysts in interglacial deposits, with the lithologic interpretations being made independent of the dinocyst results in Salabarnada et al, CP (https://doi.org/10.5194/cp-2017-152).

However [**if**] the authors choose to respond to this comment, at a minimum the abstract should be adjusted to removed the implication that glacial/interglacial has been investigated for the entire record (line 46), as only Oligocene samples have been explored for this variability, and I strongly suggest marking clearly on Figures 6 and 7 which lithologies represent glacial and which interglacial deposition, or perhaps grouping samples together - the seven columns/lithologies do not communicate clearly the variability the authors claim to have identified.

We agree with the reviewer, a new version of the manuscript will present the dinocyst data in fewer lithologic groups. Moreover, the detailed lithologic interpretations will be continued into the Miocene part of the sequence. This will only reinforce the interpretations of different dinocyst assemblages between glacial and interglacial deposits.

(3) The authors rely on unpublished (submitted, in review) work to justify their division of the dinoflagellate cyst assemblage into in situ and reworked components. This is an important step in their data processing, and important to completely assess this paper, but the information is not available to review at present.

The paper is now published and available open access in Journal of Micropalaeontology.

(4) The discussion is fairly speculative/not well supported by the data presented – but is thought provoking, and should be retained.

Because the reviewer does not substantiate which part he/she finds speculative, we cannot reply any further to this comment at this stage. We will thoroughly revisit the discussion and evaluate any speculative aspects.

Minor comments follow:
L299 relation not relations -**done**
L353 can the authors discount input of terrestrial nutrients instead of upwelling? **We can for most of the record, with reason and argument, not with unequivocal proof. Given the relatively small catchment area, and deteriorated climate, the low relative abundance of palynomorphs (those that are there are mostly wind-transported pollen) and absence of terrestrially-derived amorphous organic matter, and the average outer neritic/oceanic nature of the dinocyst assemblage, we argue for marine nutrients instead of terrestrially-derived. Although, the Miocene Climatic Optimum might have an additional terrestrially-derived nutrient source. We shall add this to the manuscript.**

L422 replace 'a close position' with 'proximal'? **This was not found, possible lost in revision**
References:

Esper, O. and Zonneveld, K.A.F.: Distribution of organic-walled dinoflagellate cysts in surface sediments of the Southern Ocean (eastern Atlantic sector) between the Subtropical Front and the Weddell Gyre, Marine Micropaleotology, 46, 177-208, 2002.

Harland, R. and Pudsey, C. J., 1999. Dinoflagellate cysts from sediment traps deployed in the Bellingshausen, Weddell and Scotia seas, Antarctica. Marine Micropaleontology. 37, 77-99.

Hartman, J.D., Bijl, P.K., Sangiorgi, F., et al., in prep-a. Palynological assemblages from the Holocene of IODP Site U1357A, Wilkes Land margin, Antarctica. to be submitted to Journal of Micropaleontology

Hartman, J.D., Sangiorgi, F., Bijl et al., in prep-b. A multi-proxy reconstruction for MIS5 to MIS9 of the Antarctic marginal ice zone in the Ross Sea: sea-ice cover, productivity and temperature for Site AS05-10, Drygaski basin. to be submitted to Paleoceanography and Paleoclimatology.

Houben, A.J.P., Bijl, P.K., Pross, J., Bohaty, S.M., Passchier, S., Stickley, C.E., Röhl, U., Sugisaki, S., Tauxe, L., Van De Flierdt, T., Olney, M., Sangiorgi, F., Sluijs, A., Escutia, C., Brinkhuis, H.: Reorganization of Southern Ocean plankton ecosystem at the onset of Antarctic glaciation, Science, 340, 341-344, 2013.

Marret, F. and De Vernal, A., 1997. Dinoflagellate cyst distribution in surface sediments of the southern Indian Ocean. Marine Micropaleontology. 29, 367-392.

Prebble, J. G., Crouch, E. M., Carter, L., Cortese, G., Bostock, H., Neil, H., 2013. An expanded modern dinoflagellate cyst dataset for the Southwest Pacific and Southern Hemisphere with environmental associations. Marine Micropaleontology. 101, 33-48.

Sangiorgi, F., Bijl, P.K., Passchier, S., Salzmann, U., Schouten, S., McKay, R., Cody, R.D., Pross, J., Van De Flierdt, T., Bohaty, S.M., Levy, R., Williams, T., Escutia, C., Brinkhuis, H.: Southern Ocean warming and Wilkes Land ice sheet retreat during the mid-Miocene, Nature Communications, 9 (1), art. no. 317, 2018.

Storkey, C.A.: Distribution of marine palynomorphs in surface sediments, Prydz Bay, Antarctica. MSc thesis Victoria University of Wellington, New Zealand. http://hdl.handle.net/10063/21, 2006.