Answer to Referee Dr. S. Pekar for the interactive comment on "Late Oligocene obliquity-paced contourite sedimentation in the Wilkes Land margin of East Antarctica: implications for paleoceanographic and ice sheet configurations" by A. Salabarnada et al.

We apologize for the late response but I have been embarked on a research cruise in Antarctica with very limited internet connection. Firstly, we would like to thank the reviewer, Dr. Steve Pekar, for his comments and constructive suggestions, which will improve the manuscript. Below, we address the main concerns of Dr. Pekar in cursive font:

Concern 1: "…major concern with the manuscript was it stating about the lack of IRD in their studied interval is taken to indicate the relative absence of marine-terminating ice sheets at the nearby margin. I have to differ with this important result as in another study by D. Hauptvogel, identified IRD's in the same interval at Site U1356. He did this by counting grains larger than 150 microns in many samples within this interval. In approximately 25% of his samples within the same interval used in this manuscript contained significant numbers of >150 micron grains usually between 2 and 5%. In addition, the sand percent for the Late Oligocene is not much less than what is seen in the early Oligocene from Site U1356. I remember that Dr. Hauptvogel spoke with the lead author back in 2016 and he sent her his sand percentage data as well as visually showed her the work he had done on the sand fraction. While there could be an argument that bottom currents could move fine sand size grains, medium size grain sized grains were also identified. So I am not sure if grains larger than 150 microns could easily be moved from the Mertz Shear Fracture (source of the grains based on Ar/Ar dating) to Site U1356 only by bottom water currents. At the very least, the authors need to discuss and explain this point far better."

We agree with the reviewer that the absence of IRD in our studied interval is not to be taken as the sole evidence for lack of marine terminating ice sheets in the Wilkes Land margin. We first want to point out that we reach this conclusion not only based on the absence of IRDs but also other supporting evidence such as: (1) the lack of sea ice indicated by the dynocists (Bijl et al companion paper to this one in CP); (2) elevated sea surface temperature (Hartmann et al. companion paper to this one in CP); and (3) palynomorph data (Salzmann et al 2016). The reviewer however, questions our conclusion because, in the study of Dr. Hauptvogel, IRD grains were identified, which contradicts our findings. As Dr. Pekar mentions, we discussed and compared our data sets during a meeting but we did not had his sand percentage data from his PhD thesis, that was available online (Hauptvogel, 2015) (https://academicworks.cuny.edu/cgi/viewcontent.cgi?referer=&httpsredir=1&article=1980&context=gc_etds). We like to note that the grains interpreted as IRD in Dr. Haupvogel´s thesis are, as Dr. Pekar indicates in his review, those that have a grain-size >150 microns. We like to emphasize that in Dr. Haupvogel thesis, these grains are considered as IRD based on the assumption that, as stated by Dr. Pekar in his review, grains larger than 150 microns cannot easily be moved from the Mertz Shear Fracture to Site U1356 only by bottom water currents. This implies that Dr. Hauptvogel assumes that sand grains >150microns can only be delivered to the

continental rise site U1356 by icebergs (as also stated in page 48 from Hauptvogel 2015, PhD Thesis). However, globally, sand and gravels can be transported to deep areas of the basins by multiple processes such as are Mass Transport Deposits (MTDs), turbidity currents, hyperpycnal flows, etc. In fact, during Expedition 318 moderately-to-well sorted, sandy granule-pebble sediments grading upwards into well-sorted fine, crudely stratified sands were recovered from Site U1355 at 3729 m water depth at the mouth on one of the submarine channels (Escutia et al., 2011). Also on the Wilkes Land, a sample collected by the USNS Eltanin from one of the Wilkes Land continental rise channels, has high-content in sand and rock fragments (Payne and Conolly 1972; Escutia et al., 2000). These findings point to delivery of very coarse material from the continental shelf to the continental rise by gravitational processes. Therefore, the assumption that >150 microns sand grains can only be delivered by icebergs to where our site is located is not accurate. Also, note that in our manuscript, we do not claim the sand to be delivered by bottom currents as implied in Dr. Pekar´s review. Instead, our facies analyses points to sediments delivered to where site U1356 is located on the continental rise, dominantly by gravity flows and hemipelagic sedimentation, which are then reworked by bottom currents.

Concern 2: "I also have some concerns with the age model, as there is only one good tie point for the late Oligocene, which is at 26.1 Ma. The spectral analysis looks good in figure 6 until 25.8 Ma but looks far more uncertain above, probably because the age model is not well resolved".

*We use the three paleomagnetic chrons by Tauxe et al. 2012. Using the two different statistical approaches provided in the manuscript and the Suplementary, we arrived to a well-resolved age model that considers two strong tie points: one in the top of the studied core interval and another one at the bottom (*Chron C8n.1n (o), 25.260 Ma, at 643.37 mbsf; and C8n.2n (o), 25.900 Ma, at 678.98 mbsf*). We will clarify in the revision that the age control, although reliable is of is low-resolution.*

Concern 3: "I think that the statement about ice in the lowlands versus the coast or versus the highlands is a bit speculative. Especially since there are no data that estimates ice volume in this manuscript as well as that there are grains larger than 150 microns that C2 occur throughout the late Oligocene section at Site U1356.

We agree with the reviewer that our data does not provide ice volume estimates. We see the confusion caused by the way the sentence is written. Of course, the ice caps and glaciers occupied lowlands as well topographic highs. In our sentence, we mainly wanted to emphasize the different topography of the Wilkes subglacial Basin, which in the Oligocene was not yet over-deepened. We will try to clarify this by rephrasing the sentence to "These observations, supported by elevated sea surface paleotemperatures and the absence of sea-ice, suggest that between 26 and 25 Ma open water conditions prevailed and therefore glaciers or ice caps occupied the topographic highs and lowlands of the now over-deepened Wilkes Land subglacial Basin."

Concern 4: " The evidence of NCW to explain the glacial /interglacial changes seen here are a bit thin. The papers cited are explaining long term trends not at Milankovitch timescales. I would suggest that this be discussed in a better way.

We like to clarify that we do not use NCW to explain glacial/interglacial cyclicity. The cyclicity in our record is explained by the alternation of facies, which we find are astronomically forced, at 40Kyr. Based on the unusual presence of calcareous coccolithospheres in some of the intervals in our record (at <60º S latitude), we hypothesise that during higher than normal interglacials a proto-CDW may have been influenced by warmer NCW as the Polar Front was displaced to the south. Similar interpretations are provided in other studies in sediments of Pliocene-Pleistocene age around the Southern Ocean recording the striking presence of calcareous nannofossils (Kuhn and Diekmann, 2002; Cowan et al., 2008; Villa et al., 2012)

Concern 5: " I don't understand how precession suggests a dynamic ice sheet."

We agree with the Reviewer that precession can have different interpretations in our record. Although highly speculative, as our record captures the precession frequencies, we suggested that high latitude summer insolation during late Oligocene had an influence on the continental terrigenous fraction suggesting ice melt and rapid ice-sheet volume changes as Patterson et al., (2014) also suggested for core U1361 in Wilkes Land during the Pliocene. However, given that this interpretation does not add to any of the relevant point of the manuscript and is highly speculative, we will remove it.

Concern 6: "The last paragraph of the conclusions is speculative as there is little data to support it."

We agree with the reviewer. We reformulated the paragraph in order to be more precise and expose only the data where we are confident.

References:

Bijl, P.K., Houben, A.J.P., Hartman, J.D., Pross, J., Salabarnada, A., Escutia, C., Sangiorgi, F., 2017. Oligocene-Miocene paleoceanography off the Wilkes Land Margin (East Antarctica) based on organic-walled dinoflagellate cysts. Clim. Past Discuss. 2017, 1–43.

Cowan, E.A., Hillenbrand, C.D., Hassler, L.E., Ake, M.T., 2008. Coarse-grained terrigenous sediment deposition on continental rise drifts: A record of Plio-Pleistocene glaciation on the Antarctic Peninsula. Palaeogeogr. Palaeoclimatol. Palaeoecol. 265, 275–291.

Escutia, C., Brinkhuis, H., Klaus, A., Scientists, I.E. 318, 2011. Expedition 318 summary, in: Proceedings of the Integrated Ocean Drilling Program, Volume 318.

Escutia, C., Eittreim, S.L., Cooper, a K., Nelson, C.H., 2000. Morphology and acoustic character of the antarctic Wilkes Land turbidite systems: Ice-sheet-sourced versus river-sourced fans. J. Sediment. Res. 70, 84–93.

Hartman, J.D., Sangiorgi, F., Salabarnada, A., Peterse, F., Houben, A.J.P., Schouten, S., Escutia, C., Bijl, P.K., 2017. Oligocene TEX86-derived seawater temperatures from offshore Wilkes Land (East Antarctica). Clim. Past Discuss. 2017, 1–31.

Hauptvogel, D.W., 2015. The State Of The Oligocene Icehouse World : Sedimentology , Provenance , And Stable Isotopes Of Marine Sediments From The Antarctic Continental Margin. PhD Dissertation. The City University Of New York.

Kuhn, G., Diekmann, B., 2002. Late Quaternary variability of ocean circulation in the southeastern South Atlantic inferred from the terrigenous sediment record of a drift deposit in the southern Cape Basin (ODP Site 1089). Palaeogeogr. Palaeoclimatol. Palaeoecol. 182, 287–303.

Patterson, M.O., McKay, R., Naish, T., Escutia, C., Jimenez-Espejo, F.J., Raymo, M.E., Meyers, S.R., Tauxe, L., Brinkhuis, H., Klaus, a., Fehr, a., Bendle, J. a. P., Bijl, P.K., Bohaty, S.M., Carr, S. a., Dunbar, R.B., Flores, J. a., Gonzalez, J.J., Hayden, T.G., Iwai, M., Katsuki, K., Kong, G.S., Nakai, M., Olney, M.P., Passchier, S., Pekar, S.F., Pross, J., Riesselman, C.R., Röhl, U., Sakai, T., Shrivastava, P.K., Stickley, C.E., Sugasaki, S., Tuo, S., van de Flierdt, T., Welsh, K., Williams, T., Yamane, M., 2014. Orbital forcing of the East Antarctic ice sheet during the Pliocene and Early Pleistocene. Nat. Geosci. 7, 841–847.

Payne, R.R., Conolly, J.R., Aabbott, W.H., 1972. Turbidite Muds within Diatom Ooze off Antarctica: Pleistocene Sediment Variation Defined by Closely Spaced Piston Cores. GSA Bull. 83, 481–486.

Salzmann, U., Strother, S., Sangiorgi, F., Bijl, P., Pross, J., Woodward, J., Escutia, C., Brinkhuis, H., 2016. Oligocene to Miocene terrestrial climate change and the demise of forests on Wilkes Land, East Antarctica, in: EGU General Assembly Conference Abstracts, EGU General Assembly Conference Abstracts. p. EPSC2016-2717.

Villa, G., Persico, D., Wise, S.W., Gadaleta, A., 2012. Calcareous nannofossil evidence for Marine Isotope Stage 31 (1Ma) in Core AND-1B, ANDRILL McMurdo Ice Shelf Project (Antarctica). Glob. Planet. Change 96–97, 75–86.