

## Reply on EC1: Community comment response

Michael Amoo et al.

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Author comment on "Eocene to Oligocene vegetation and climate in the Tasmanian Gateway region were controlled by changes in ocean currents and  $p\text{CO}_2$ " by Michael Amoo et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-131-AC1>, 2022

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### Community comment: Ian Sluiter

**Discussion comment:** *I write ... to provide a few short comments on the paper by Amoo et al. on Late Eocene to Early Oligocene vegetation of the Tasmanian Gateway Region in the hope that it may improve their paper, but also set some ground rules for future authors from the Northern Hemisphere who wish to work on pollen records from this part of the Southern Hemisphere. My name is Ian Sluiter, and I am happy for you to provide the comments to the authors with my name known. I have been working on, and will publish very soon, a terrestrial pollen record from Gippsland (Victoria) which lies ~730km to the NNW of ODP1172. That is ~5.5degrees latitude north. The general thrust of a warming episode at our site mirrors the changes recorded by Amoo et al., but I am not exactly sure how this has come about.*

*The major criticism I have of the paper are outlined below.*

**Response:** We thank the author of these discussion comments for giving us the opportunity to clarify important aspects of this study. We are pleased to hear that their unpublished findings from the coal seams of the Gippsland Basin largely mirror the results from ODP Site 1172 presented in our study. The potential issues raised in his comments are not "hemisphere-specific", but rather result from differences between the site-specific depositional environments and related sedimentology of their terrestrial and our marine site presented in this study (see below).

**Discussion comment:** *The Methods of the paper declare that a 15-micron sieve was used to presumably clean unwanted organic and inorganic matter. To do so with Australian pollen records (Quaternary or Tertiary) is a disaster. For the Eocene to Early Oligocene vegetation and climates with which this paper is concerned, sieving excludes anywhere between 2-30% of the pollen sum; and potentially 5-70% of the Miocene pollen sum if the authors propose any work on these age sediments. This means all Cunoniaceae taxa bar larger Weinmannia, all Elaeocarpaceae, many of the small Myrtaceae including core taxa like Syzygium, along with Quintinia, Macaranga/Mallotus, Bluffopollis (Strasbergeria), Ulmaceae and even small Proteaceae would be washed down the sink!*

**Response:** Sieving marine palynological samples is a standard technique and is required to remove unwanted organic/inorganic matter, and to increase the pollen concentration which is much lower in marine sediments than in terrestrial peat samples. Like Contreras et al. (2014), who covered the Early Eocene vegetation record of site 1172, our Eocene-Oligocene study reanalysed slides from the same batch of samples that were originally processed for marine palynology at the Laboratory of Palaeobotany and Palynology of Utrecht University. We systematically compared samples sieved at 15 and 10 µm from the adjacent site ODP 1168 (western Tasmanian margin, Amoo et al. in prep) and ODP site 696 (Drake Passage; Thompson et al., 2021) and found no differences. Small pollen grains from e.g., *Myrtaceidites* and *Cupanieidites* are present in small quantities (<1-2%) in all batches.

Unfortunately, the author of the discussion comment provides no reference for his estimate of up to 70% loss of pollen grains due to sieving, but we can certainly exclude such a loss in our labs, as we also regularly control the sieving residues. However, we agree that sieving (like many other lab procedures which are unfortunately necessary) potentially increases the risk of losing small pollen grains. Following their comments, we will add respective remarks to our method section.

**Discussion comment:** *This is a very serious loss of data and necessarily simplifies any vegetation reconstructions. Moreover, the use of diversity indices like S-W and Evenness become redundant.*

**Response:** We do not have any evidence for a “loss of data”. How vegetation is reflected in a pollen record is strongly influenced by the location, depositional environment, and sedimentology. In this regard, a pollen record from a marine core provides indeed a “simplified” picture of the terrestrial vegetation if compared to a terrestrial peat bog record which archives the full diversity of the local swamp vegetation. Regardless of the geological time or continent, particular caution should be exercise when comparing biodiversity from pollen records from different depositional environments. We therefore use the index to record relative changes at this ODP site only. In response to concerns raised in the discussion comments, we will make this restriction clearer in our method section and explain the particular limitations of marine pollen records.

**Discussion comment:** *This is a marine pollen record from 250km ESE of Tasmania. A Lat/Long at Line 64 would be appreciated.*

**Response:** The coordinates of Site 1172 are already provided in chapter 2.1 (line 83) which includes the site description. In case of a misunderstanding, we slightly reworded this part to make it clearer that these coordinates refer to the coring site, and not to the East Tasman Plateau. We could not find any reference for the estimate of 250 km, and we therefore keep our estimate of ~170 km southeast of Tasmania with reference to the 1172 Shipboard Scientific Party (2001).

**Discussion comment:** *The record seriously over-records the importance of Pteridophytes, at least when compared with terrestrial records from Tasmania and*

*Gippsland.*

**Response:** We do not understand why our sporomorph record “seriously over-records Pteridophytes”. The late Eocene total spores at site 1172 on average accounts for about 11% of all non-reworked sporomorphs, and this resembles the spore percentage abundance trend of the terrestrial T1 Coal Seam (late Eocene/Middle *N. asperus* Zone) records from the Gippsland Basin and Otway Basin in southern Australia (Holdgate et al., 2017).

**Discussion comment:** *The vegetation descriptions about Tasmanian vegetation at the time lack substance. I have never seen an Australian Tertiary record without Myrtaceae! I presume they must have been washed down the sink which makes the description a whole lot easier, I guess!*

**Response:** Myrtaceae (i.e., *Myrtaceidites*) and *Dacrycarpus* (i.e., *Dacrycarpites*) also occur in the pollen record of Site 1172. We think there might be a misunderstanding. The pollen diagram (Fig. 2) does include selected taxa only, as indicated in the figure caption. A full list of all taxa (raw dataset) including those occurring with percentages <1% can be found at <https://doi.org/10.5281/zenodo.5924930>. Here we followed Climate of the Past publication guidelines and uploaded the raw count dataset onto an appropriate data repository.

**Discussion comment:** *This is an Australian - Not New Zealand Tertiary Record*

*Most of the pollen ID's seem to be aligned with NZ Tertiary taxa, and not with Australian pollen taxa. It is easy to quote Ian Raine I guess, as Australia do not have a compendium like NZ has. But to do so comes with some basic flaws and oversights.*

**Response:** Raine et al. (2011) is to date the most complete and detailed illustrated pollen and spore catalogue available for pre-Quaternary studies of the southern high latitudes. We therefore prefer to stay with this catalogue as the first reference. We are certainly happy to adapt the Australian nomenclature if this helps to improve our reconstruction (see response below regarding *Nothofagidites* nomenclature).

**Discussion comment:** *It is possible the Sapotaceae palynomorph may be the smaller Sapotaceoidaepollenites cf latizonatus, but I doubt it. I would suggest it is more likely to be S. rotundus*

**Response:** The pollen at 1172 is a small grain and we therefore keep

*Sapotaceoidapollenites cf latizonatus*.

**Discussion comment:** Comments on Particular Pollen Taxa

*I also have some comments on the Nothofagaceae. Nothofagidites flemingii is a Fusca Type B (sensu Dettmann et al.) but belongs in the modern genus Nothofagus. I would not be combining it in with Fuscospora. Fuscospora and Nothofagus need to be separated in the pollen diagram.*

*I would not be using the NZ Brassospora pollen types Nothofagidites mataurensis and N. cranwelliae in an Australian pollen diagram. They are very similar morphologically to N. emarcidus and this is the pollen taxon I would combine them with. UNLESS one or both of the pollen types were the square sided N. heterus (Cookson) Stover and Evans 1973 which is very common at times in contemporaneous age fossils from Gippsland to the north. If N. heterus has not been recorded – I ask why not?*

*Nothofagidites lachlaniae? Another NZ pollen type which is probably best aligned in an Australian context with N. incrassatus (Cookson) Dettmann.*

**Response:** We identified clear morphological differences between the *N. matauraensis*, *N. cranwelliae* and *N. emarcidus* taxa. Morphologically, *N. cranwelliae* and *N. emarcidus* complex do have the same slightly concave to straight sides, however, while spines on *N. cranwelliae* decrease in density from poles toward the equator, *N. emarcidus* has these spines evenly distributed across the grain (Dettmann et al., 1990; Prebble, 2016). *N. matauraensis* can mostly be distinguished from *N. cranwelliae* and *N. emarcidus* by its characteristic pentagonal shape.

To simplify our taxonomy and make it easily relatable to Australian taxonomy, we followed the author of this discussion comment suggestion and combined *N. emarcidus*, *N. cranwelliae* and *N. matauraensis* into the *Nothofagidites emarcidus* complex. For *Nothofagidites lachlaniae*, we respectfully disagree that this taxon is more aligned to New Zealand pollen types as previous studies have also found them in Australia (e.g., Pole, 2001). However, to address the concerns raised, we modify the *N. lachlaniae* to *Nothofagidites lachlaniae* complex to make it more comparable to a previously published Paleocene to Eocene record of Contreras et al. (2014) from Site 1172.

With respect to *Nothofagidites flemingii*, we are reluctant to add it to the modern subgenus *Nothofagus*. As this is a Paleogene record, we prefer to use the conventional nomenclature and keep taxonomic distinction between modern plants and the fossil palynomorphs. Also, we mentioned in our manuscript (lines 260-261) that we categorised our *Nothofagidites* pollen taxa into *Brassospora*, *Lophozonia*, and *Fuscospora* following Dettmann et al. (1990). We therefore would like to keep our categorisation this way as Fusca Type B is considered *Fuscospora* according to Dettmann et al. (1990).

It is however important to note that, the above-described taxonomic revisions do not affect the vegetation and climate interpretations.

**Discussion comment:** A comment on *Phyllocladidites mawsonii*. This pollen taxon hits some pretty big numbers further north in Gippsland at the same time. I am seriously curious as to its relatively low representation at ODP1172, especially given the loss of the smalls down the sink. Perhaps it is due to over-representation from the spores.

**Response:** Based on our records from Site 1172, *Phyllocladidites mawsonii* represents one of the common pollen taxa as we mentioned in Section 4 (lines 237-238) of our manuscript, and in some instances making up to 17% of our non-reworked sporomorphs. The differences in representation of *Phyllocladidites mawsonii* may be site specific, and most likely independent of relative percentages of Cryptogams. This is further supported by representation of *Phyllocladidites* from previously published Eocene records in Site 1172 (Contreras et al., 2014) being comparable to those presented in our records. Nevertheless, it is apparent that *Phyllocladidites mawsonii* may have been overrepresented in terrestrial Gippsland Basin records as compared to same taxon recovered from the Middle *Nothofagidites asperus* Zone in the Groper-1, Mullet-1 and Bluebone-1 wells, offshore Gippsland Basin, southeast Australia (Partridge, 2006b). Coincidentally, the percentage abundance of *Phyllocladidites mawsonii* presented from our marine pollen record on the ETP (ODP Site 1172) is comparable to those recovered offshore Gippsland Basin. We will add this information to our revised manuscript.

**Discussion comment:** What is *Spinizonocolpites* sp.? This genus? *Nypa* is well gone (extinct) by the Late Eocene from southeastern Australia. No evidence is forthcoming for it at the same time in Gippsland further to the north. Can the authors be absolutely sure that this is not Early Eocene re-working?

**Response:** Our *Spinizonocolpites* pollen grain is significantly smaller than 30 microns and we therefore preferred to call this *Spinizonocolpites* sp. (*Spinizonocolpites*-type; Martínez et al., 2016) with Arecaceae being the nearest living relative (NLR), rather than calling it *Spinizonocolpites prominatus* with *Nypa fruticans* being the NLR. However, according to Macphail et al., (1994), the middle Eocene extinction of *Nypa* in the Gippsland Basin are considered to be mostly local and not representative of a region-wide event. Region-wide extinction of megathermal taxa such as *Nypa fruticans* and *Cupanieae* are reported to have occurred in the late Eocene and they never crossed into the early Oligocene (Read et al., 1990; Macphail. et al., 1994). These are consistent with our pollen record as our *Spinizonocolpites* sp. pollen do not cross into the Oligocene. The taxon also occurs together with other warm loving taxa throughout the Late Eocene, providing further support for a synsedimentary deposition. For further clarification, we will add these comments to the revised manuscript.

**Discussion comment:** I also question what the entity/identity of *Malvacearumpollis mannanensis* might be?

**Response:** *Malvacearumpollis mannanensis* has an overall circular or spherical shape with circular pores that are usually found in the equatorial region (Prebble, 2016). The pollen

grain is covered with conical spines that are evenly distributed. Morphologically, though this taxon may be similar to *Malvacipollis*, its larger (44-85  $\mu\text{m}$ ) size separates the two taxa. This taxon forms one of the minor components in Australian Paleogene forests (Macphail and Hill, 2018).

**Discussion comment:** *Figure 1: Tasmania is a small island compared to the mainland of Australia, but not as small as the scale bar would indicate. This shows a measurement of 50km, when the actual distance is nearer to 120km!!*

**Response:** This might be a print calibration issue. Our scale shows a measurement of ~110 km and not 50 km. Fig. 1 is certainly not for scale, and to avoid future issues, we removed the scale bar entirely from the figure.

**Discussion comment:** *Figure 3: Do not quote Holdgate et al. 2017, for the Gippsland Basin spore pollen zonation. This belongs with Stover and Partridge (1973); Partridge (2006). The pollen zonation age is also wrong. Please have the authors correct the position of the Middle and Upper *N. asperus* Zone boundary to 33.9Ma as Partridge (2006) places it. I would also like to see a small stratigraphic zonation discussion of how this boundary was arrived at.*

**Response:** We used the pollen zonation of Partridge (1999) where they placed the boundary between the middle and upper *N. asperus* Zone at 33.7 Ma. We agree this needs to be updated and the boundary shifted to 33.9 Ma as in Partridge, (2006a). However, the age of the core is well-constrained by magnetostratigraphy, dinocyst, nannoplankton, and diatoms (see Bijl et al., 2021; Houben et al., 2019). We therefore removed the pollen zonation from Fig. 3 as it is not relevant to this study.

## References

- Bijl, P. K., Frieling, J., Cramwinckel, M. J., Boschman, C., Sluijs, A. and Peterse, F.: Maastrichtian–Rupelian paleoclimates in the southwest Pacific – a critical re-evaluation of biomarker paleothermometry and dinoflagellate cyst paleoecology at Ocean Drilling Program Site 1172, *Clim. Past*, 17(6), 2393–2425, doi:10.5194/cp-17-2393-2021, 2021.
- Contreras, L., Pross, J., Bijl, P. K., O'Hara, R. B., Raine, J. I., Sluijs, A. and Brinkhuis, H.: Southern high-latitude terrestrial climate change during the Palaeocene-Eocene derived from a marine pollen record (ODP Site 1172, East Tasman Plateau), *Clim. Past*, 10(4), 1401–1420, doi:10.5194/cp-10-1401-2014, 2014.
- Dettmann, M. E., Pocknall, D. T., Romero, E. J. and Zamaloa, M. del C.: *Nothofagidites* Erdtman ex Potonie, 1960; a catalogue of species with notes on the paleogeographic distribution of *Nothofagus* Bl. (southern beech), *New Zeal. Geol. Surv. Paleontol. Bull.*, 60, 1–77, 1990.
- Holdgate, G. R., Sluiter, I. R. K. and Taglieri, J.: Eocene-Oligocene coals of the Gippsland and Australo-Antarctic basins – Paleoclimatic and paleogeographic context and

implications for the earliest Cenozoic glaciations, *Palaeogeogr. Palaeoclimatol. Palaeoecol.*, 472, 236–255, doi:10.1016/j.palaeo.2017.01.035, 2017.

Houben, A. J. P., Bijl, P. K., Sluijs, A., Schouten, S. and Brinkhuis, H.: Late Eocene Southern Ocean cooling and invigoration of circulation preconditioned Antarctica for full-scale glaciation, *Geochemistry, Geophys. Geosystems*, 20(5), 2214–2234, doi:10.1029/2019GC008182, 2019.

Macphail, M. K., Alley, N. F., Truswell, E. M. and Sluiter, I. R. K.: Early Tertiary vegetation: evidence from spores and pollen, in *History of the Australian vegetation: Cretaceous to Holocene*, edited by R. S. Hill, pp. 189–261, Cambridge University Press, Cambridge., 1994.

Macphail, M. K. and Hill, R. S.: What was the vegetation in northwest Australia during the Paleogene, 66–23 million years ago?, *Aust. J. Bot.*, 66(7), 556–574, doi:10.1071/BT18143, 2018.

Martínez, L. C. A., Archangelsky, S., Prámparo, M. B. and Archangelsky, A.: Early Cretaceous palm pollen tetrads from Patagonia, Argentina, *Cretac. Res.*, 59, 129–139, doi:10.1016/j.cretres.2015.10.023, 2016.

Partridge, A. D.: Late Cretaceous to tertiary Geological Evolution of the Gippsland Basin, Victoria, Latrobe University, Bundoora, Victoria 3083, Australia., 1999.

Partridge, A. D.: Late Cretaceous-Cenozoic palynology zonations Gippsland Basin, in *Australian Mesozoic and Cenozoic Palynology Zonations*, Geoscience Australia, edited by Montiel, E., 2006a.

Partridge, A. D.: New observations on the Cenozoic stratigraphy of the Bassian Rise derived from a palynological study of the Groper-1, Mullet-1 and Bluebone-1 wells, offshore Gippsland Basin, southeast Australia., 2006b.

Pole, M. S.: Can long-distance dispersal be inferred from the New Zealand plant fossil record?, *Aust. J. Bot.*, 49(3), 357–366, doi:10.1071/BT00022, 2001.

Prebble, J. : Descriptions and occurrences of pollen and spores from New Zealand Cenozoic sediments., 2016.

Raine, J. I., Mildenhall, D. C. and Kennedy, E. : New Zealand fossil spores and pollen: an illustrated catalogue, GNS Sci. Misc. Ser. no. 4 [online] Available from: <http://data.gns.cri.nz/sporepollen/index.htm> (Accessed 9 August 2021), 2011.

Shipboard Scientific Party: Leg 189 Summary, in *Proceedings of the Ocean Drilling Program, 189 Initial Reports*, Ocean Drilling Program., 2001.

Thompson, N., Salzmann, U., López-Quirós, A., Bijl, P. K., Hoem, F. S., Etourneau, J., Sicre, M.-A., Roignant, S., Hocking, E., Amoo, M. and Escutia, C.: Vegetation change across the Drake Passage region linked to late Eocene cooling and glacial disturbance after the Eocene–Oligocene Transition, *Clim. Past Discuss.*, 2021, 1–39, doi:10.5194/cp-2021-84, 2021.