Reply to: *Interactive comment on* "Climate, cryosphere and carbon cycle controls on Southeast Atlantic orbital-scale carbonate deposition since the Oligocene (30–0 Ma)" by Anna Joy Drury et al.

Anonymous Referee #1 (R1)
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We would like to take this opportunity to thank R1 for taking time to review our manuscript and for providing such constructive feedback that will help improve the overall manuscript. Please see our responses to this feedback below.

Drury et al., present a new XRF (Ca/Fe) record that extends the previously published study of Liebrand et al., 2016 from early Miocene into Pleistocene. CaCO3 content estimated from this new dataset provides the first composite record in the South Atlantic with a continuous astronomical chronology for the last 30 Ma. Through wavelet analysis, Drury et al., find that the variability and dominant cyclicity in %CaCO3 content have evolved over time. Overall, 3 distinct stages are recognized: from 30 to 8 Ma, eccentricity paced cyclicity dominates %carbonate variability. After 8 Ma, obliquity and precession become more prevalent while eccentricity imprint is reduced. In the last 3 Ma, both precession and obliquity become hard to observe and the age model relies on previously published benthic d18O (Bell et al., 2014). The manuscript is well written, and the dataset has the potential to make a great contribution to the community and serve as a framework for future palaeoclimatic and palaeoceanographic studies. I thus suggest acceptance of the manuscript with some minor revision.

We are pleased to hear that R1 values the progress we have made regarding the stratigraphy and understanding of the dominant cyclicities in carbonate content in the Angola basin for the past 30 Ma, and our dissemination of these results in the paper.

My primary concern about the studied site is the potential complications of winnowing. Sites of Leg 208 were drilled to provide a depth transect in the South Atlantic to monitor changes in ocean chemistry as a function of time and depth. However, a submarine edifice such as the Walvis Ridge also forms a major obstacle to the flow of deep and intermediate waters. Sediments deposited on such a topographic high can be highly winnowed due to intensified flow of waters around and over the ridge. Shackleton et al. (1984) have also studied the accumulation rate of fine fraction along the depth transect of Leg 74 and concluded that winnowing has removed fine-grained material from topographic highs and deposited them on the flanks and in the basins.

We agree with R1 that winnowing could have affected accumulation rates at Site 1264 and we will take this mechanism into account in the revised manuscript. However, we also note that Site 1264 is not positioned on the shallowest parts of the Walvis Ridge bathymetry (which are less than a km deep) and is situated on a very gentle slope. With palaeo-water depths between 2 and 2.5 km, the site was situated above the lysocline and CCD.

Unfortunately, we currently do not have independent constraints on winnowing throughout the entire 30 Myr interval (sample processing is still in progress), but if we interpret fine fraction weights for the interval between 30 and17 Ma (Liebrand et al. 2016, their Fig. 2) as a proxy for winnowing, this would suggest that winnowing is modest during the "mid" Oligocene, increasing during late Oligocene warming and relatively high across the Oligocene-Miocene Transition. During the early Miocene (post OMT, pre-mid Miocene) winnowing is comparable to late Oligocene values, and increase toward the more condensed middle Miocene part of the Site 1264 record. We will expand the results to include these observations and will take this mechanism into account in the discussion.

I also take a look at the biostratigraphy of Site 1264 in the initial report. I find that 1) the highest occurrence of D. tamalis is ~18 mcd and 30 mcd at Site 1264 and 1266, respectively; 2) the highest occurrence of D. pentaradiatus is ~16 mcd and 26 mcd at Site 1264 and 1266, respectively; 3) the highest occurrence of D. brouweri is ~11 mcd and ~20 mcd at Site 1264 and 1266, respectively; the list can go on. The point here is that the deeper Site 1266 (3800 meters) has much higher carbonate accumulation rates (~ doubled) than the shallower Site 1264. This difference cannot be due to productivity and is unlikely due to dissolution. The most possible interpretation therefore is that strong winnowing has significantly affected the carbonation accumulation of Site 1264.

We thank R1 for pointing out these differences between the 1264 and 1266 biostratigraphy in the upper succession. The discrepancy certainly indicates that the lower accumulation rates in the upper interval (certainly the upper 30 or 40 mcd) cannot/is unlikely to arise from productivity and/or dissolution. However, for the deeper intervals, the sedimentation rates increase at 1264 relative to 1266, which decreases the discrepancy between older biostratigraphic events. Certainly, for the late Miocene interval, the 1264 sedimentation rates are similar or higher than 1266, which would mean productivity remains a valid mechanism to explain these differences. Nonetheless, we agree with R1 that winnowing needs to be considered and that there are intervals where winnowing likely significantly influenced carbonate accumulation at Site 1264. We will therefore add a discussion of this biostratigraphic argument to the paper, especially in the context of what it reveals about how winnowing may act as an additional mechanism controlling $CaCO_3$ deposition at 1264.

I do not rule out the possibility that changes in carbonate accumulation and %CF can be partially explained by changes in primary productivity at Site 1264. However, can authors provide some other evidence to support their interpretation of a change in primary productivity? Alternatively, if winnowing is important at Site 1264, could it compromise the %$CaCO_3$ records and how it might affect the spectrum properties? For instance, could winnowing explain obscure cyclicity in the last 3 Ma at Site 1264? I think these are open questions but the authors should be aware of the potential complication at this location.

Our observation linking the inverse relationship between carbonate content/mass accumulation rates and %CF to productivity were only associated with the biogenic bloom interval in the late Miocene. We will make sure this is clearer in Section 5.3. As commented above, the sedimentation rates at 1264 increase relative to those at 1266 during the late Miocene and are either similar or higher at 1264 compared to 1266. We will certainly discuss the implications of the relative occurrence of biostratigraphic events between 1264 and 1266 across the 30 myr interval, but we think winnowing is less likely to have influenced carbonate deposition during the biogenic bloom interval compared to productivity. Although we do not have direct evidence of productivity during this time, we think increased productivity remains a valid interpretation considering the greatly increased sedimentation rates at Site 1264 and the presence of similar increases in carbonate deposition linked to increased productivity at other locations around the globe.
The effect of low sedimentation rates on spectral power at Site 1264 is well explained and explored for the Oligocene and early Miocene in Liebrand et al., 2016. Unfortunately, they did not suggest winnowing as a mechanism, but we agree with R1 that this topic should be considered and will expand our discussion as such. We will especially also consider how winnowing may explain the low carbonate values and lack of clear cyclicity in the last 3 Ma.

ref: Shackleton, N. J. (1984). Accumulation rates in Leg 74 sediments. Initial Reports of the Deep Sea Drilling Project, 621-644.

We will include this reference in the discussion about how winnowing may affect carbonate deposition at Site 1264.

Other comments:
Figure 2 caption suggests that the black and green records are magnetic susceptibility. The label of y axis, however, is XRF (Ca/Fe).

Thank you for spotting this error. The y-axis should be labelled shipboard magnetic susceptibility and we will correct this.

Page 7, Line 10: a typo?

Thank you, we have corrected “for” to “four”.

P14, the authors relate the recovery of %CaCO3 ∼14.5 Ma to changes in dissolution.
The study of Kender et al., 2014 (benthic foram B/Ca) can be helpful.

ref. Kender, S., Yu, J., & Peck, V. L. (2014). Deep ocean carbonate ion increase during mid Miocene CO 2 decline. Scientific reports, 4, 4187.

Thank you, we were not aware of this study, it certainly supports that the appearance of precession ~13-14 Ma may in part be due to less seafloor dissolution. We will take their results into account in this discussion, as well as considering the potential influence that winnowing may have.