Reply to Reviewer Comment #2

Dear Professor Evan Edinger,

Thank you for dedicating your time and expertise to reviewing our manuscript. Your comments and constructive feedback have been very helpful and we believe that addressing your suggestions has significantly improved the quality of this work.

From your general comments, we identify three main points. We will address these first in a summary, and then reply to your specific comments in detail (your comments in italics, new text in the manuscript underlined).

1. *It would be even more valuable if the complete record or carbon(ate) accumulation rates from the longer off-mound cores were presented […]*
2. *Similarly, they could refer to published off-mound cores from elsewhere in the region that might extend back to MIS 11, should they exist (they probably do) / we need a longer record from the off-mound site.*
3. *what about the integral of the total accumulation through time?*

We are grateful for this suggestion which has led to a few additions to the manuscript (see also new text provided in the detailed comment section), and extended the interpretation of our study. First, we now show the full range of our off-mound carbon accumulation, and present mean and min-max ranges. Most importantly, we have identified and integrated the only known published sediment core from the Southern Alborán Sea (ODP161-979A) that extends back to MIS11, to allow for a full comparison between the history of Dragon Mound and the background sedimentation, i.e., the common seafloor. Due to IODP standard procedures, organic and inorganic carbon content, as well as sediment density were measured and are available online, along with a biostratigraphic age-depth model. The organic and inorganic carbon accumulation rates from our off-mound core record match well with the background rates from the ODP core, which suggests that the off-mound cores are representative for the area and that it is reasonable to use the ODP core as off-mound reference site for older coral mound formation phases. Compiling the ODP data underlines that also during earlier, enhanced formation stages, the CWC mound accumulates more carbon than the background environment.

By adding the background carbon accumulation rates from ODP161-979A, we are now able to make a fully integrated comparison of total carbon accumulation comparison over the entire time span of 400 kyr of mound formation. We first outline how our off-mound cores can only document part of the mound formation history, and then, through ODP161-979A, provide evidence that, even across multiple glacial cycles, despite > 200 kyrs of missing on-mound sedimentation, the total carbon accumulation is higher on the CWC mound than in the background record. All these outlined additions are also illustrated in Fig. 6 of the new manuscript.

We also appreciate your perspective on further spatial upscaling beyond the scope of this paper; indeed, this aspect is already planned to be addressed as a deliverable of our next research project and a further motivation.

Specific Comment Responses:

All minor, non-content related suggestions, e.g., general phrasing, abbreviations, references, were accepted and integrated into the new manuscript. These and all in-line comments that refer to a concern that has already been addressed before, are not listed individually in this response in order to make the response letter more manageable.

remove "so-called" from text, as well as quotation marks for common terms

Response: We fully agree and have applied the suggested changes throughout.

L53: [CWC mound carbonate accumulation is in the same range as tropical coral reefs etc.] This is arguable - I think a caveat is appropriate - they can be in the same range, that is overlap the range, but in general, we are looking at g/ m2/ y, not kg/ m2/y, like G, as used for warm-water coral reef carbonate budgets.

Response: We added "can be", instead of "is / are".

L142: keV instead of kV?

Response: In fact, x-ray source generator units are given in kV.

L. 160: This sounds analogous to the core "decompression" based on kinematics, like what IFREMER has been doing. Similarly, should publish whatever kinematic or other data are used to calculate revised depths.

Response: For clarification, we applied some minor changes to the section (see L.184f). Here we need to deal with post-drilling core expansion, and apply a "linear squeeze", i. e. core compression scaling, where each core data point from the CT scan is recalculated by linear interpolation to a new depth through the MeBo-specific standard length of 235 cm (100% recovery) per barrel. It is necessary here to assume that the expansion was proportional to the total length of the core barrel. As suggested, we publish the depth model along with our data points in PANGAEA.

L. 247: why not overlaps? Two records are better, no ?!

Response: Yes, a full analysis of both cores (TIC/TOC and DBD) would generally be better. Yet, there was certainly a budget limitation to double-measuring the same record twice. Based on the matching coordinates of the two cores, we define the two cores to be in the same location. Secondly, as the ages / stratigraphies do overlap, we can be confident to create one continuous "off-mound" record, with the longer core MD13-3457 from 12 kyrs BP onwards. However, also upon your helpful suggestions later in the review, we decided to compare our off-mound results to the only other known core from the region (ODP161-979A) and find that our mean off-mound rates on carbon accumulation lie in the same range, suggesting our record is representative for the purpose of this study (see above).

L. 266: Remind us what is the origin of the 12.01/100.09 value at the end, since it has not units. Is this based on the atomic weight of carbon, vs CaCO3?

Response: Yes indeed, this is the atomic weight ratio of carbon vs. carbonate (in molar mass g mol^{-1}, unit added to text in new version). Since we quantify the coral (i.e., carbonate) volume and mass in the analysis / equation first, it is necessary to convert to carbon at the end. Slight correction added.

L. 420: The timing is pretty interesting - MIS 5c, MIS7b - so not at the peaks of either integlacial, and during the cooling limbs of MIS 9 and MIS 11. Presumably the timing is discussed somewhere - if in Wienberg et al. 2022, then that should be referenced, and a short summary repeated.

Response: Indeed, the timing is heavily discussed in Wienberg et al. 2022. Following your comment, we add a very brief summary of the interpretation of CWC mound formation timing in the Alborán Sea in the "Regional Setting" introduction section in L. 93ff. of the new manuscript: "[…] Mound formation phases in the EMCP correspond mainly to interglacial periods, but also to one glacial period (MIS 10). While there is no clear link between phases of active CWC mound formation and ice age-paced climate oscillations, there seems to be a strong coupling with changes in the African hydroclimate (see Wienberg et al., 2022 for a detailed description)." We also reference Wienberg et al. (2022) in the Age Model and Results section (L.190ff and L.354ff, respectively) when describing the results for Dragon Mound and list the marine isotope stages that correspond to the mound formation phases presented.

Jointly listed:

L. 461, 501, 602 / Fig. 4: Here, it is REALLY important to present the full history of C burial in the off-mound core.

L.490.2: But, what about the integral of the total accumulation through time? […] Which one sequesters more C over time?

Response: This is a very valuable point raised. As outlined above, we aim to address all these concerns through adding ODP core 161-797A to our interpretation and integrating total carbon accumulation over the full ~400 kyr of record. We also include the full range of our off-mound accumulation into our interpretation now (GeoB13731-1 and MD13-3457) and all TIC/TOC data of the entire record will be published in PANGAEA. While a detailed analysis and the palaeoceanographic interpretation of the background carbon accumulation dynamics in the Southern Alborán Sea goes beyond the scope this paper, we provide a first compilation, which may also be helpful for further studies on regional marine carbon cycles. We compare, as suggested, the total integrated carbon accumulation over ~400 kyr in Dragon Mound vs. background seafloor. We applied changes as outlined above, which involved a restructuring of the discussion section "5.4 Cold-water coral mounds as carbon sinks." The new addition (L.

691ff) to the text is provided here: "In addition to comparing carbon accumulation rates during the mound formation phases, assessing the total long-term net carbon burial throughout a mound's entire existence (i.e., Dragon Mound, ~400 kyr) in both on- and off-mound settings may provide further insight into the potential role of CWC mounds in the marine carbon cycle. Notably, there were extensive periods without any mound formation or carbon accumulation (see hiatuses, Fig. 3), whereas off-mound accumulation is expected to be continuous. However, our off-mound record is comparably short (~126 kyr) and only overlaps with one mound formation phase on Dragon Mound. A stratigraphically longer off-mound record, preferably spanning the full record of Dragon Mound from initiation until present, would allow a much more meaningful comparison. Sediment core records documenting ~400 kyr of carbon accumulation are scarce in the Southern Alborán Sea – The only available off-mound sediment core record that provides the necessary data is ODP Leg 161 Hole 979A (Comas et al., 1996; ODP Shipboard Scientific Party, 1996), at 1062 mbsl (35°43.427'N, 3°12.353'W; data sources: https://web.iodp.tamu.edu/OVERVIEW/?&exp=161&site=979, biostratigraphic age model from De Kaenel et al., 1999). To assess the applicability of this ODP core as a valuable off-mound counterpart to our on-mound record from Dragon Mound, we first compare it to the off-mound record analysed in this study. Over the last >100 kyr, the herein presented off-mound record (originating from cores GeoB13731-1 and MD13-3457) with a mean organic carbon accumulation rate of 0.2 g Corg cm-2 kyr-1 (range: 0.03 – 0.7 g Corg cm-2 kyr-1) is comparable to the 0.3 g Corg cm-2 kyr-1 (range: 0.1 – 0.5 g Corg cm-2 kyr-1) in the ODP core. Similarly, mean inorganic carbon accumulation of 0.9 g Cinorg cm-2 kyr-1 (range: 0.3 – 3.6 g Cinorg cm-2 kyr-1) at our off-mound site is very close to 1.0 g Cinorg cm-2 kyr-1 (range: 0.7 – 1.3 g Cinorg cm-2 kyr-1) in the ODP core. Consequently, also the mean total carbon accumulation rates in both cores are quite similar with 1.1 g C cm-2 kyr-1 (range: 0.3 – 4.3 g C cm-2 kyr-1) and 1.3 g C cm-2 kyr-1 (range: 0.9 – 1.7 g C cm-2 kyr-1), respectively, highlighting the regional consistency of off-mound net carbon burial through time. Correspondingly, our off-mound core record represents not only local, but also regional off-mound accumulation dynamics well suited to the purpose of this study.

Finally, the integration of net carbon burial for on- and off-mound (GeoB18116-2 vs. ODP161-979A, respectively) over the complete evolution of Dragon Mound since mound initiation, i.e., the last ~400 kyr, covering several glacial-interglacial cycles, reveals that total carbon accumulation at Dragon Mound (649 g C cm-2) is 20% higher than at the off-mound site ODP161-979A (544 g C cm-2; Fig. 6 in the new manuscript). Importantly, this is observed despite >200 kyr of non-sedimentation on the mound. In this direct comparison the extensive

BRIfinal mound formation phase, widely recorded in the EMCP (see Wienberg et al., 2022), cannot be considered as it is not documented at Dragon Mound. Thus, for other CWC mounds in the EMCP, the surplus on-mound carbon accumulation might be even higher."

L.490: What about the differences in space? How much of the Alboran sea had mounds in it during the Holocene or in MIS 5?

Assessing the volumes of the mounds (or even their footprints only) would require adding another somewhat complex methodology here – morphometrics. This would significantly increase the length of this manuscript and presents a study in itself. However, the very different mound formation histories for the individual mounds, see Wienberg et al. (2022), would add another level of complexity to do such a spatial analysis. To our feeling, this would overload the paper. Generally, the relative fraction of the seafloor covered by CWC mounds is likely to be minor. On the other hand, large stretches of the continental slopes' seafloor off NW Africa that have been mapped, do have CWC mounds present (for example, > 1500 km^2 off Atlantic Morocco, Hebbeln et al., 2019), and many parts of the South Alborán seafloor are unexplored. We further mention the limitations of spatial upscaling in our conclusion (L.753).

L.490 / Table 4: Since comparing the organic carbon concentrations becomes important later on in the discussion, it would be important to report the number of measurements included, and to present an average, standard error, and maybe even a statistical comparison of mound vs off-mound.

Response: We added the number of measurements and the standard deviation (SD) to Table 4. Beyond that, a statistical comparison would indeed be a great idea, which would however need more measurements and go beyond the scope of this study.

L. 526: This is not a complete sentence. Some were locally absent, and some were locally displaced. Those two are quite different.

Response: Thank you for spotting this! We adapted the sentence (L. 541f) and added references. "For instance, present-day shallow-water reefs are carbonate factories that swing between states of active formation and extinction, being locally absent or displaced due to periodic sea-level fluctuations and associated environmental change (e. g., Schlager, 1981; Milliman, 1993; Camoin and Webster, 2015; Wood et al., 2023)."

L. 561: This graph could be improved in two ways.

First, all of the points in this study should have labels (for the different DM phases, and for the 1 phase from BRI. Similarly, the 6 points from previous studies should also have location labels added to them. Finally, adding the background values from the off-mound core here would be valuable, and would show that the low accumulation rate portions are still somewhat elevated above "background" (off-mound) carbon accumulation rates.

Response: Following your suggestion, we revised this graph and added the labels to the graph and it is now much more informative. We also tried to add the two off-mound records, however, while we agree that it would be good to see them there too, they are not part of the regression curve, and also would overload the lower part of the graph. As this section only focusses on the mounds themselves, we think it is appropriate to only present the mound records here. Yet, through changes outlined above, our new graph including the much longer published off-mound core shows how low mound accumulation rates and off-mound rates relate. Notably, upon reviewing the graph, we also decided to remove the data point from Urania Bank, since it comes from a "CWC talus deposit" and not a mound *sensu stricto*. However, this increased the R^2 to 0.97.

L. 595: yes, unless submarine canyons are a major source of sediment, as in some regions of the NE Atlantic.

Response: Great point, we replaced "naturally" by "generally".