Response on RC1

The paper presents carbonate clumped isotope records of modern and Last Glacial Maximum (LGM) land snails from the island of Lanzarote, as well as LGM climate records simulated by various climate models. They found that temperatures reconstructed from LGM fossil snail carbonate clumped isotopes (Δ47-T(°C)) were −8.4 ± 2.9 °C lower than modern values (Δ47-T(°C)), and this cooling magnitude was greater than those simulated by all climate models included in this study. It is widely recognized that reconstructing precipitation $\delta^{18}O$ using the evaporative snail body water flux model requires multiple variables. In this study, the authors constrained temperature using shell carbonate clumped isotopes and fixed relative humidity at approximately 90% based on the physiological traits of land snails in the study area and previous studies, thus reconstructing LGM precipitation $\delta^{18}O$ (δ18Oprecipitation). Moreover, previous studies suggested that paleosol layers on Lanzarote indicate a more humid condition during the LGM. Based on previous work, the authors proposed that the high humidity derived from the Evaporative Snail Body Water Flux Model represents microenvironmental humidity. They further linked marine water to δ18Oprecipitation and $\delta^{18}O_{shell}$. After ice-volume correction, $\delta^{18}O_{shell}$ together with $\delta^{13}C_{shell}$ confirms a more arid climate in the study area during the LGM. Currently, terrestrial paleoclimate records are mainly concentrated in mid- and high-latitude regions. On Lanzarote, it is difficult to find geological archives other than land snails that can be used to accurately reconstruct regional temperatures using carbonate clumped isotopes. Therefore, this study provides a new perspective for paleoclimate reconstruction in the low-latitude eastern Canary Islands during the LGM. In addition, the authors' approach of constraining the humidity parameter in the evaporative snail body water flux model based on snail physiological characteristics, as well as their strategy for validating the reliability of the humidity parameter, is also excellent. However, there are also some problems that should be solved in this paper. The study repeatedly mentions that land snails on Lanzarote ingest dew water, which originates from the condensation of marine vapor. Nevertheless, this study did not consider the dew water isotope effect and directly equated the snail-imbibed water $\delta^{18}O$ output by the flux model with precipitation $\delta^{18}O$. Meanwhile, given the high sensitivity of relative humidity in this model, the validation of constraining relative humidity at 90% may also be challenged.

Thank you for your thoughtful feedback about the sensitivity of the Balakrishnan and Yapp snail body water flux model. We acknowledge that dew consumption may play a confounding influence on the interpretability of d18O, and do encourage others consider it with a modified model approach. However, we do not model the influence here because it is out of the scope of the study. We have instead chosen to acknowledge the limits of our study, and will incorporate the citation of Da (2025).

Specific comments:

Line 28-29: "Proxy data indicate that LGM mean annual air temperatures ~8.4 °C ± 2.8 °C cooler than…"

This sentence is missing the predicate were.

We have fixed the grammatical sentence structure. Thank you for catching this error.

Line 51-53: "on the island of Lanzarote to assess both the modern climate and the Last Glacial

Maximum (~23-24 ka)."

The LGM is defined as ~21 ka in Line 21, but your LGM samples are dated to ~23-24 ka. It is

recommended that you revise the term to early Last Glacial Maximum (early LGM).

We have amended this statement to say "early Last Glacial Maximum (~23-24 ka)."

Line 174: Bao et al., 2023

The bibliography does not contain this reference.

Thank you, we have fixed this error and added the referenced work to the bibliography.

Line 227 -228: "... do not exhibit any season-dependent change in behavior."

It is a little bit arbitrary to state that there are no seasonally related behavioral changes here. This contradicts lines 370-372, where the lower temperatures reconstructed from clumped isotopes are attributed to the cold preference of snails.

In lines 227 – 228, we write fully: "Given that the temperatures and humidity of the island exceed or match these constraints, individuals are to be active year-round and do not exhibit any season-dependent change in behavior." In lines 369 – 372, we write: "Cooler temperatures in the modern dataset may therefore correspond to snails active during the winter season, while warmer temperatures indicate snails primarily active during the summer." – which does not communicate differential cold preference among snails, rather that the temperatures are hypothesized to be explainable due to snails that were active solely during wintertime, thus capturing a majority wintertime signal.

Line290: "$R_{sbw} = \alpha_{w\text{-}v}(\alpha_k (1 - h_{surf}) R_{surf} + h_{surf} R_{vap})$"

The original formulas in Balakrishnan & Yapp (2004) and the Craig-Gordon model of lake evaporation include the ratio of water outflow flux (other than evaporation) to water inflow flux.

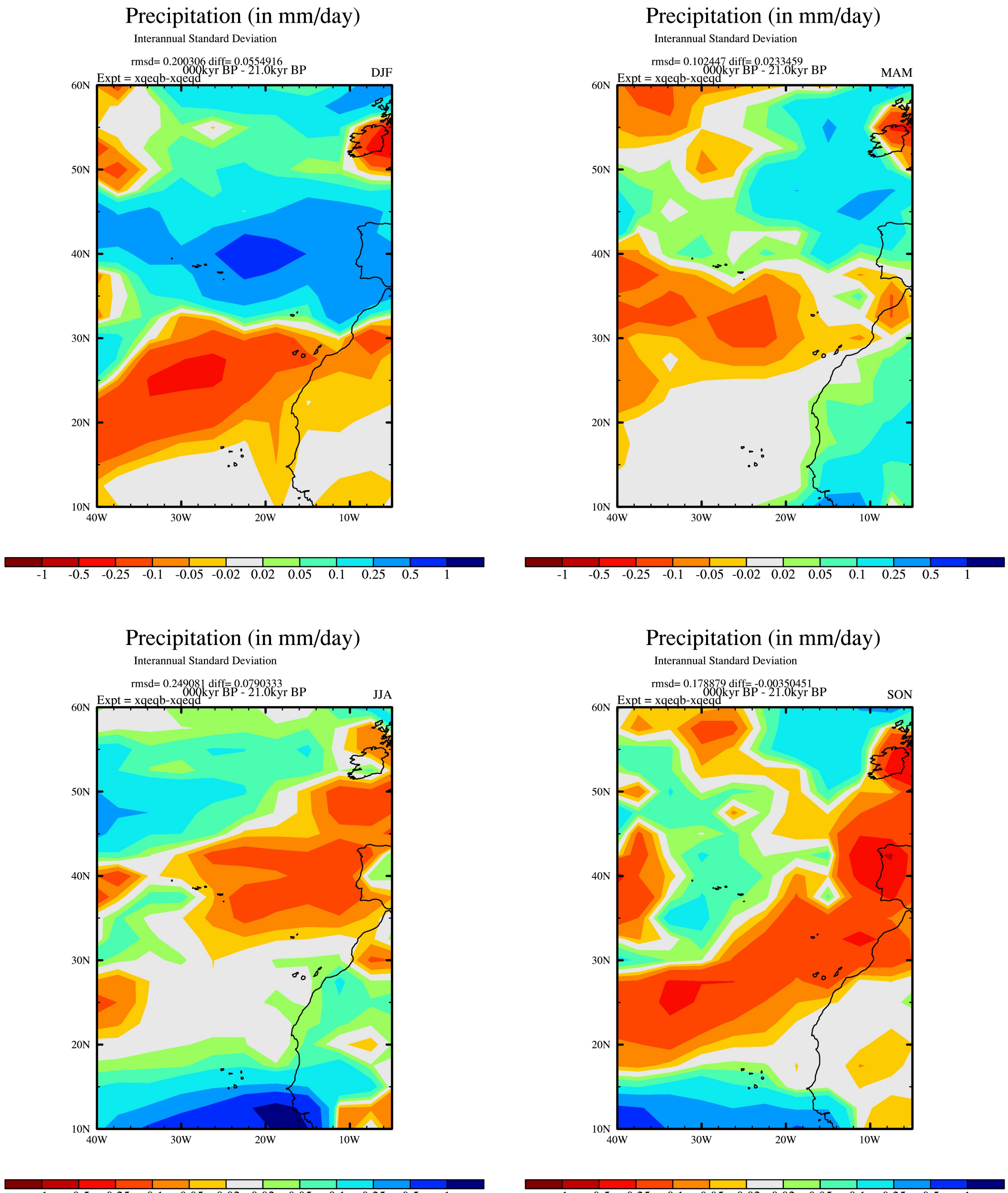
You have set this ratio to 0 by default here. It is suggested that you explain why you assume nearly all snail body water is lost via evaporation.

We follow the methodology of Eagle et al. 2013 which employ the same assumption, which is that direct loss of liquid water is negligible compared to loss due to evaporation, thus set to 0. We have clarified this adjustment to the equation in the text.

Line 437-438: "Therefore, it is possible that a rainout effect during the wintertime leads to more depleted values relative to the present."

The explanation that the Hadley Centre model simulates more negative winter δ18Oprecipitation due to a rainout effect caused by approximately half an inch more winter precipitation during the LGM than in the pre-industrial period is somewhat unconvincing. First, you do not specify the actual difference in δ18Oprecipitation between the LGM and the present. Second, it remains unclear whether this half-inch precipitation difference falls within the model simulation error, making it difficult to assess the magnitude of the rainout effect exerted by such a small precipitation anomaly on the δ18Oprecipitation.

The model agrees well with modern GNIP database results (https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2008JD010825). The seasonal preindustrial – LGM anomaly is emphasized in winter and autumn and is about ~1 mm/day which is quite low and suggests that internal model variability could be investigated. The model produces a 50-year climatology to reduce internal variations (such as interannual and interdecadal). The anomaly is spatially large, suggesting that the simulated difference between the climate states is attributable to large-scale dynamics, such as changing storm tracks. The 1-sigma change in precipitation shows only small change in precipitation in the winter (-0.25:-0.05 mm/day), while the autumn has a larger standard deviation that is still relatively small. The precipitation shift and likely the isotope shift associated with it is not due to internal model variability. We provide a figure of the 1-sigma change from the simulation repository that illustrates the standard deviations of the precipitation data. There are no standard deviation files or plots available for the isotope data, but it should follow the climate signal indicated by the precipitation output. We have included some of this interpretation in the manuscript text.



Line484-487: "so the Balakrishnan & Yapp model produces results consistent with lower relative humidity at these warmer temperatures,"

It is mentioned that the LGM temperature reconstructed from snail carbonate clumped isotopes is warmer than winter temperatures. Please clarify which climate model was used to simulate these winter temperatures and provide the specific temperature values. In addition, do you think this argument is reasonable?

This discussion is not referring to simulated temperatures, as direct comparison to the LGM simulation's temperatures is not appropriate due to potential model biases. The discussion is referring to comparison with modern empirical wintertime temperatures. To clarify, we have added the qualifier "modern" to the sentence.

Line459 -462: "The reconstructed δ18Oprecipitation values for both modern and LGM datasets are indistinguishable from one another (-4.6 ‰, 95% C.I. = 0.6 for the modern, and -4.7 ‰, 95% C.I. = 0.6 for the LGM once corrected), suggesting that while temperatures were cooler at this site during the LGM relative to the present, the cumulative δ18Oprecipitation signal remained the same."

You reconstructed δ18Oprecipitation using the Balakrishnan & Yapp (2004) snail flux-balance model.

However, you implied in Lines 523-524 and Lines 207-208 that snails may ingest dew as a water source. Jiawei Da (2025, CG; Isotopic evidence for dew uptake by land snails from Bayesian modeling of body water δD and δ18O) demonstrated that a high proportion of dew intake by land snails can lead to overestimated relative humidity from the flux-balance model output. I suggest you add a sensitivity analysis to evaluate how dew proportion affects the retrieved humidity and $\delta^{18}O$ of snail-ingested water.

We thank the reviewer for drawing attention to Da (2025). We consider a full sensitivity analysis of dew proportion to be outside of the scope of our study. We used the Balakrishnan & Yapp (2004) model to isolate and compare differences in evaporative state between the modern and LGM datasets; the model was not being used here to reconstruct absolute relative humidity values, which are the output most directly affected by the dew-proportion issue identified by Da (2025).

Line488-490: "The LGM land snail samples are also unlikely to be indicative of full summertime growth because the calculated relative humidity is greater than 100% -- not physically impossible, but likely an implausible circumstance given the proximity to a major dust source that could trigger condensation."

Since there is nearly no summer precipitation, using summer precipitation isotopes to simulate relative humidity becomes meaningless. In Lines 494-496, it has already been stated that isotopic data from modern snail shells better match the late spring to early autumn period. It is therefore suggested that the simulation should instead use precipitation isotope data for this time window directly.

Our initial comparison to summertime conditions was exploratory – to highlight that while summertime might have provided snails with more favorable temperatures, our proxy data does not match this condition as well. We have provided updates to figures showing $\delta^{18}O_{precipitation}$ and precipitation where the mean annual, DJF, and JJA conditions of the Hadley Centre isotope-enabled model are compared to include MAM and SON.

Line547-548： "...the reconstructed δ18Oprecipitation values show a possibility of aridity driving enrichment of heavy isotopes."

You attribute the heavier δ^{18}Oshell values after ice-volume correction to evaporation. According to my understanding, "heavier" here means that δ^{18}Oshell is heavier than the δ^{18}Oshell derived from theoretical fractionation based on LGM δ18Oprecipitation. You also mentioned in lines 528–530 that the LGM precipitation baseline is −3.5‰ and the seawater baseline is 1.08‰. Therefore, is it possible that a higher proportion of dew consumed by land snails caused δ^{18}Oshell to be heavier than theoretical expectation? Please evaluate the impact of this scenario on your aridity assessment.

As stated earlier, while the effect of dew on the shell and body water isotopes is a valid scenario to explore, our study does not incorporate it.