Point-by-point reply letter to review comments

Revised manuscript #egusphere-2025-2996

"Penultimate glacial sea surface temperature and hydrologic variability in the tropical South Pacific from 150 ka Tahiti corals" *by *R. Asami, T. Felis, R. Shinjo, M. Murayama, Y. Iryu (*Corresponding author: R.A.)*

We deeply thank the editor (Dr. Stephen Obrochta) for handling our manuscript and two anonymous reviewers for providing useful comments on our manuscript. Following the comments, we addressed all of them and improved the manuscript accordingly. You can see the changes highlighted in red in the revised manuscript and the responses to reviewer's comments in the reply letter.

Reply to the comments (Reviewer #1)

Comment (#1-1, Line 15) *"Abstract: The new monthly-to-bimonthly resolved Sr/Ca and $\delta^{18}O$ records from fossil Tahiti corals spanning MIS 6b, MIS 3a, and the last glacial provide valuable insights into past tropical-subtropical Pacific climate variability. However, the manuscript could more clearly separate the influence of large-scale atmospheric changes (e.g., SPCZ/ITCZ shifts) from local oceanographic processes such as upwelling or current-driven changes. While uncertainties related to intercolony $\delta^{18}O$ variability are acknowledged, it would be helpful to clarify how consistent the signals are across coral samples and how representative the records are. The comparison with YD and HS1 is interesting—could the authors elaborate on whether similar forcing mechanisms, such as freshwater fluxes or AMOC slowdowns, might explain the patterns observed across these distinct time intervals?"*

----- Thank you so much for providing useful and positive comments. In this study, it is impossible to distinguish between atmospheric influences and local oceanographic drivers due to lack of paleoclimate proxies and model simulations at 153-148 ka and 30 ka. However, some climate simulation studies indicate pronounced lower SSTs in the Pacific and reduced ENSO

variability during the LGM, which can support lower activity of the SPCZ. Following the comment, we added the explanation "This climatic interpretation could be supported by a simulation study suggesting that the WPWP contracted to the west and the SST gradient became stronger in the equatorial Pacific during the LGM (Thirumalai et al., 2024)" in this paragraph [Line 361-363 of the revised manuscript with highlighted].

As you pointed out, uncertainties of intercolony d18O variability (±0.12‰, Sayani et al., 2019) enable to present the significant difference of d18Osw between modern and MIS 6b (and 3a), but not to discuss the difference between MIS 6b and 3a. Following your comment, we added the explanation "Considering the inter-colony $\delta^{18}O$ variability of ±0.12‰ (Sayani et al., 2019), $\delta^{18}O_{sw}$ differences between glacial periods and the present are significant. However, we cannot discuss the difference among 153 ka, 148 ka, and 30 ka corals for paleoclimate interpretation." in the Discussion [Line 255-257 of the revised manuscript with highlighted].

Thank you again for providing your useful suggestions on a relation between AMOC slowdowns and our fossil coral records. As you pointed out, εNd and Pa/Th records from the Atlantic Ocean show higher values during 153 ka and 148 ka (MIS 6b) and 30 ka (MIS 3a) relative to interglacial periods, indicating weaker AMOC activity (Bohm et al., 2015 Nature; Deaney et al., 2017 Nature Communications). So, we added the explanation in the Discussion "Radiogenic neodymium isotope and $^{231}Pa/^{230}Th$ records from Atlantic marine sediments show higher values at 153 ka, 148 ka, and 30 ka as well as during the YD relative to interglacial periods (Böhm et al., 2015; Deaney et al., 2017), which might suggest atmospheric teleconnections in transferring climate signals from the Atlantic to the tropical Pacific for MIS 6b and 3a associated with slowdowns of the Atlantic meridional overturning circulation (McManus et al., 2004; Timmermann et al., 2007)." [Line 378-382 of the revised manuscript with highlighted].

"Questions:

1. How were uncertainties propagated in the reconstruction of $\delta^{18}O\_sw$, *particularly given the sparse number of fossil coral samples?*

2. What independent evidence (e.g., model outputs or other paleoclimate proxies) supports the proposed contraction or weakening of the SPCZ during MIS 6b and MIS 3a?

3. Given the resolution of the coral records, were any spectral or wavelet analyses performed to identify interannual variability (e.g., ENSO frequencies)? If not, could the authors comment on the feasibility of such analysis?

4. Could the authors clarify how seasonal SST and $\delta^{18}O\_sw$ values were extracted from the records? Was a sinusoidal fit or another method used to determine summer vs. winter means?"

----- [Q1] The errors in d18Osw reconstructions were calculated to be maximum in this study. As you pointed out, it is expected that future works will reduce the uncertainty by increasing the number of fossil coral samples during the same periods and reducing the errors of past sea level estimations.

[Q2] Unfortunately, we cannot find no direct evidence of model outputs and paleoclimate records around the study site during the time intervals. However, some indirect evidence of climate simulations and ice core records during glacial cold periods can support our interpretations of SPCZ variability (Lambert et al., 2008; Cao et al., 2019; Krätschmer et al., 2022). PMIP3/4 simulations show that LGM tropical precipitation decreases, resulting in the southward shift, narrowing, and weakening of the ITCZ at the global scale (Wang et al., 2023 JGR). The Indonesia stalagmite d18O records show that the ITCZ convection strength was weaker during the LGM than the Holocene (Yuan et al., 2023 PNAS). Furthermore, a recent study of biomarker and pollen proxies from French Polynesia indicates that the tropical region (8.9°S, 140.1°W) in the central South Pacific was colder and drier during the glacial period, especially 35-25 ka, than today (Peaple et al., preprint in PNAS). Results of these previous studies can further support our climate interpretations and we included the additional explanations in the discussion "A climate modelling study shows that tropical precipitation decreases during the LGM, resulting in the southward shift, narrowing, and weakening of the ITCZ (Wang et al., 2023), which is consistent with the Indonesia stalagmite

$\delta^{18}O$ records (Yuan et al., 2023). These lines of evidence for a weakened ITCZ during the LGM can further support our fossil coral records, which suggest a weakened and/or northwestward-contracted SPCZ during MIS 6b and 3a." [Line 301-305 of the revised manuscript with highlighted] and the papers in the References.

[Q3] As you know, the ENSO variability has a periodicity of 3-to-8 year/cycle. Unfortunately, the fossil corals have very short records (only 10-yr time series at most from a 148 ka coral). At least 20-year-long time series should be needed to quantitatively verify the ENSO signals using MTM or wavelet spectral methods. So, in this study, we focus the investigation on the mean state and seasonality of the climate.

[Q4] The summer maximum and winter minimum SSTs were derived from the lowest and highest coral Sr/Ca values in any given annual Sr/Ca cycle. And, the d18Osw values in the summer SST maximum and winter SST minimum months were used to discuss thermal and hydrological differences in summer and winter between the past and today. Following your comment, we added the explanations "Annual maximum and minimum Sr/Ca values in a fossil coral are used as annual minimum and maximum SSTs recorded in winter and summer for paleoclimate interpretation. The seawater $\delta^{18}O$ values in the maximum and minimum Sr/Ca-SST months were used to discuss hydrological differences in summer and winter between the past and today in this study." in the method [Line 148-151 of the revised manuscript with highlighted].

Comment (#1-2, Line 41-42) *"The phrase "tropical-to-subtropical South Pacific" is a bit vague. You might consider adding specific coordinates or boundaries (e.g., 10°S–25°S, or regions between Tahiti and the GBR) to help the reader understand the spatial focus."*

----- Following the comment, we added "0°S–20°S" in the sentence [Line 42 of the revised manuscript with highlighted].

Comment (#1-3, Line 58-62) *"While you state that the fossil coral records are monthly-to-bimonthly resolved and U-Th dated, I am curious whether, given the chronological uncertainty of U-Th dating, the monthly signal can be confidently resolved* *in glacial-age corals. Since most readers are more familiar with the Last Glacial Maximum (LGM), it would help to briefly define or reference the time range of the penultimate glacial period (~MIS 6) to reinforce its significance."*

----- We apologize for using the expressions that may have misled you. The time accuracy is guaranteed in the monthly-to-bimonthly coral time series because the geochemical record was continuously extracted from a transect along coral growth direction. The U-Th dating result (with 2σ errors) is the period when the coral was alive. To avoid misunderstandings among readers, we deleted the phrase "precisely U-Th dated" in the sentence [Line 17 and 58 of the revised manuscript with highlighted]. The definition and reference of the time range was described in the manuscript [Line 91-94 and 278-284 of the revised manuscript with highlighted].

Comment (#1-4, Line 87) *"Change to "51-57 cm"*

----- Thank you for pointing it out. We corrected it to "51-57 cm" [Line 87 and 110 of the revised manuscript with highlighted].

Comment (#1-5, Line 89-90) *"Please clarify whether this interpolation assumes stratigraphic continuity or if the coral was directly dated and found unsuitable."*

----- Following the comment, we corrected the sentence to "From the perspective of stratigraphic succession, the mean of these two ages is used as best estimate for the age of our last glacial coral because our sample is located between those two samples in the sediment core (Fig. 2)" [Line 89-91 of the revised manuscript with highlighted].

Comment (#1-6, Line 90-92) *"You may consider briefly describing the climatic relevance of these MIS intervals (e.g., "a transitional phase preceding the PGM") to aid general readers."*

----- Following the comment, we added the explanation "..., ~~just before the start of~~ corresponding to a transitional phase preceding the penultimate glacial maximum (PGM), and 30 ka during MIS 3a, ~~just before the start of~~ corresponding to a transitional phase preceding the Last Glacial Maximum

(LGM)" [Line 92-94 of the revised manuscript with highlighted].

Comment (#1-7, Line 98) *"Please specify the thickness of slabs."*

----- Following the comment, we added the explanation "into ~1 cm thick slices" [Line 100 of the revised manuscript with highlighted].

Comment (#1-8, Line 100-101) *"Please clarify whether these segments were taken along the red sampling transect shown in Fig. 3 and how many data points this yielded for each core."*

----- Following the comment, we added the explanation "(see the rectangular areas with numbers in Fig. 3)" [Line 103-104 of the revised manuscript with highlighted].

Comment (#1-9, Line 106-107) *"This phrasing is vague. Consider rewording to: "Portions of the samples exhibited secondary aragonite and/or calcite cementation," and quantify if possible. Given that some cements were observed, it would strengthen the methodology section to explicitly describe the criteria used to distinguish acceptable from altered portions. For example: "Transects showing more than X% calcite or altered aragonite under SEM/XRD were excluded."*

----- Following the comments, we corrected the sentences to "The samples (Core 310-M0009B-17R-1W, 44-53 cm, 310-M0009D-25R-1W, 65-75cm, and 310-M0009D-25R-2W, 43-51 cm and 51-57 cm) ~~partially have~~ contain portions of well-preserved skeleton and secondary aragonite and/or calcite cements (Fig. S1). Consequently, we performed geochemical analyses on selected transects with well-preserved skeleton without any traces of diagenetic alteration (Fig. 3). Transects showing >0% calcite or the presence of aragonite cements were excluded from geochemistry in this study." [Line 108-113 of the revised manuscript with highlighted].

Comment (#1-10, Line 113) *"In the X-ray images, the growth direction is somewhat difficult to discern. Could you clarify how you determined the growth direction? Additionally, please mark the locations selected for U-Th dating on the sample images."*

----- Unfortunately, the growth direction is difficult to discern partially on X-ray images because the core slabs are about 1 cm thick. In order to take clear X-ray images, the samples should be cut to a thickness of 3-to-5 mm. However, considering the preciousness of the samples and the necessity for diagenesis screening and geochemical analyses, it was impossible to cut and shape the samples. So, we determine the growth direction using a magnifying glass. Please note that the samples for U-Th dating is not collected from our slab samples. A coral core was cut into two slabs and one is used for our study and the other one was used for U-Th dating (Thomas et al., 2009). Therefore, we cannot mark the locations of U-Th dating on the sample images.

Comment (#1-11, Line 120) *"Since $\delta^{13}C$ and $\delta^{18}O$ analyses were performed at multiple institutions (JOGMEC and Kochi University), please comment on how consistency between labs was ensured—e.g., did both use the same calibration materials, and were inter-lab replicates analyzed?"*

----- Following the comment, we added the explanation "Replicate measurements of NBS-19 and JCp-1 standard materials ensured the analytical consistency between the two laboratories" in the method. [Line 131-132 of the revised manuscript with highlighted].

Comment (#1-12, Line 122) *"While calibration against NBS-19 is mentioned, it would be useful to briefly note whether a two-point or linear correction was applied, especially for oxygen isotope ratios."*

----- The oxygen isotope value of reference gas was determined using a 5-point calibration from five international standards. The standards NBS-19 and JCp-1 were analyzed multiple times for every sequence and we confirmed that the measured values were consistent with the recommendation values.

Comment (#1-13, Line 122) *"replace "was" with "were""*

----- Following the comment, we corrected it accordingly [Line 129 of the revised manuscript with highlighted].

Comment (#1-14, Line 126-128) *"Consider revising the sentence for clarity and precision as follows:*

"Each ~0.2 mg coral powder sample was dissolved in 5 mL of 0.5 mol/L high-purity HNO3, prepared using ultrapure Milli-Q water.""

----- Following the comment, we corrected it accordingly [Line 134-136 of the revised manuscript with highlighted].

Comment (#1-15, Line 128) *"The use of Sc, Y, and Yb as internal standards, along with the application of a Ca-matched reference solution every three samples, are appropriate strategies. However, could you clarify whether internal standard correction and drift correction were applied sequentially or in combination?"*

----- Following the comment, we added the explanation "in combination with internal standard correction" in the sentence [Line 140-141 of the revised manuscript with highlighted].

Comment (#1-16, Line 133) *"The Sr/Ca reproducibility reported (better than 0.30% RSD) and agreement with JCp-1 reference values is strong. To provide additional context, you might briefly mention whether this level of precision is sufficient to resolve seasonal or interannual SST variations in your specific corals."*

----- Following the comment, we added the explanation "(equivalent to SST errors of <0.5 °C)" in the sentence [Line 142 of the revised manuscript with highlighted].

Comment (#1-17, Line 136) *"Consider breaking the paragraph into two for readability: one focusing on resolution and averaging effects, and the other on the SST/$\delta^{18}O$_sw uncertainty estimation."*

----- Following the comment, we corrected the paragraph accordingly [Line 147-171 of the revised manuscript with highlighted].

Comment (#1-18, Line 137-138) *"Here is somewhat vague. Consider clarifying what drives the variability—e.g., is it due to differing coral growth rates or diagenetic screening? Additionally, it may be helpful to specify the typical linear extension rate* *assumed to translate mm to time."*

----- Following the comment, we added the explanation "due to differing coral growth rates" in the sentence [Line 152 of the revised manuscript with highlighted]. The typical linear extension rate was described in the Results and Discussion because results of annual Sr/Ca cycles are needed to estimate the growth rates [see Line 207-208 of the revised manuscript].

Comment (#1-19, Line 139-140) *"Although SST differences were calculated using OISST v2.1, the method for converting Sr/Ca values to SST should be described more explicitly—for example, specifying the calibration equation or slope used. If this conversion is based on modern Porites calibrations, please cite the source directly here or reaffirm the slope presented in earlier sections."*

----- Following the comment, we added the explanation "In this study, we used the slope of Sr/Ca-SST calibration (r = -0.85, p < 0.01) from the composite coral Sr/Ca record from five modern Tahiti corals established in the previous study (Knebel et al., 2024)." in this paragraph [Line 162-163 of the revised manuscript with highlighted].

Comment (#1-20, Line 141) *"The calculated SST offsets (e.g., +0.07 °C and −0.09 °C) are indeed small. Still, it would be useful to state explicitly how these compare to the observed amplitude of seasonal SST changes in the fossil records. This will help readers assess whether the offsets are indeed negligible relative to the climate signals of interest."*

----- Following the comment, we added the explanation "..., which is much smaller than the amplitude (about 3−5 °C, see the discussion) of seasonal Sr/Ca-derived SST changes in the fossil coral records and analytical Sr/Ca error (< 0.5 °C)" in the sentence [Line 152-159 of the revised manuscript with highlighted].

Comment (#1-21, Line 144-145) *"This setence could be strengthened by briefly specifying whether uncertainties were combined in quadrature and whether interannual SST variability was considered in addition to analytical and calibration errors."*

----- Following the comment, we added some explanations in this

paragraph "In this study, we used the slope (−0.050 ± 0.002 mmol/mol/°C) of the Sr/Ca-SST calibration (r = -0.85, p < 0.01) from the composite coral Sr/Ca record from five modern *Porites* Tahiti corals, established in a previous study (Knebel et al., 2024). For the SST dependency of $\delta^{18}O$, the coral $\delta^{18}O$-SST calibration slope of –0.20±0.02 ‰/°C, derived from *Porites* corals in a large tropical and subtropical region (Juillet-Leclerc and Schmidt, 2001), was used. The annual average and seasonal amplitude of Sr/Ca and $\delta^{18}O_{sw}$ values were calculated for each coral sample with standard deviation (SD, 1σ). The ~~paleo-SST and~~ $\delta^{18}O_{sw}$ estimates with combined errors (CE) were calculated from the slopes of $\delta^{18}O$-SST and Sr/Ca-SST calibrations, ~~and~~ taking into account analytical errors as in a previous ~~studies~~ study (Cahyarini et al., 2008), yielding a CE of ±0.11‰ For estimations of weighted-average Sr/Ca values in coral colonies for selected periods during which the U-Th ages of fossil corals are overlapped, the CE was calculated for the root of the sum of the squares of the SD around the mean of the coral averages by following previous studies (Giry et al., 2012; Brocas et al., 2018)." [Line 162-171 of the revised manuscript with highlighted] and improved Table 1 accordingly.

Comment (#1-22, Line 146) *"Please provide 230Th age table."*

----- Please note that the U-Th measurements are not carried out in this study. The ^{230}Th age results (Table) were already published in Thomas et al. (2009). So, we cannot show the table in this study.

Comment (#1-23, Line 147) *"The paragraph is detailed and informative but could benefit from breaking into shorter sections for better readability. Consider separating the data description, interpretation, and growth rate discussion into distinct paragraphs."*

----- Following the comment, we divided the paragraph (section 3.1) into three paragraphs [Line 174-210 of the revised manuscript with highlighted].

Comment (#1-24, Line 155-156) *"The explanation about the complex interpretation of coral δ13C on glacial-interglacial timescales is helpful. If space allows, a brief summary or rationale would aid readers unfamiliar with Felis et al. (2022)."*

----- Following the comment, we added the explanation "..., as ~~has been~~ previously discussed for last deglacial GBR corals, which relate to ~~in the context of~~ the global carbon cycle, including changes in atmospheric CO_2, reef carbonate production, and the decomposition of organic land carbon (Felis et al., 2022)" in this paragraph [Line 190-192 of the revised manuscript with highlighted].

Comment (#1-25, Line 159-160) *"You might consider adding brief comments on the sample size (n) or the robustness of these statistics."*

----- Following the comment, we added the sentence "There exist significant correlations of coral Sr/Ca vs. d18O records for 153 ka (r = 0.74, n = 54, p < 0.01), 148 ka (r = 0.71, n = 89, p < 0.01), and 30 ka (r = 0.71, n = 20, p < 0.01) (Fig. 5)" in this paragraph [Line 195-197 of the revised manuscript with highlighted].

Comment (#1-26, Line 165) *"The comparison of glacial vs. modern coral growth rates is important. Consider elaborating slightly on the implications of lower growth rates for proxy reliability or potential diagenetic effects."*

----- The coral growth rates are not related to diagenetic effects, but the coral density may be related to the effects because it could depend on potential space for cements to precipitate. We do not discuss about the possibility because we do not use geochemical records of diagenetically altered coral skeleton for climate interpretation. On the other hand, we added the explanations on the relationship between coral growth rates and geochemical records in the section 3.2 "..., and for the d18O offset caused by difference in annual growth rate between modern and fossil corals using a previously established equation with an r2 value of 0.91 for eleven *Porites* spp. corals with growth rate of 2.0–15.2 mm/year (Felis et al., 2003), which is similar to other studies (Hayashi et al., 2013; Hirabayashi et al., 2013). In contrast, coral Sr/Ca data is not corrected for the Sr/Ca offset caused by differences in annual growth rate because there is no significant relationship between coral Sr/Ca and growth rates (Inoue et al., 2007; Hirabayashi et al.,

2013)." [Line 237-242 of the revised manuscript with highlighted]. Furthermore, we added a brief implication "It is noted that the effects of coral growth on geochemical records should be carefully considered for paleo-temperature estimations (see Section 3.2)." in this paragraph [Line 209-210 of the revised manuscript with highlighted].

Comment (#1-27, Line 193) *"Could you provide more detailed information on how uncertainties were propagated through the multiple correction steps? Are error bars or confidence intervals included with the final SST and δ¹⁸Osw estimates?"*

----- Following the comment, we added the information "Based on the law of propagation of data error, the errors on the SST and $\delta^{18}O_{sw}$ reconstructions were estimated from the root-sum-square of the standard deviations of parameters used for calculation." [Line 244-245 of the revised manuscript with highlighted] and at Table 1.

Comment (#1-28, Line 198) *"The assumption of a uniform 0.5% increase in seawater Sr/Ca during the LGM is based on previous studies. Is there any evidence that this value varies regionally, especially in the South Pacific? How might regional variability affect the accuracy of corrections?"*

----- There are no published papers showing regional variations of seawater Sr/Ca values in the study site. However, because the residence time of Sr and Ca in seawater is much longer (>1,000,000 years), it is expected that regional variations of seawater Sr/Ca ratios could be probably small. In this study, the assumption of 0.5% changes in seawater Sr/Ca at glacial-interglacial scale was used, but future studies on regional Sr/Ca variability will evaluate the accuracy of corrections more quantitatively using raw data of our fossil records published in this journal.

Comment (#1-29, Line 200) *"Is the assumption of present-day SST (2000–2008 AD) as the baseline appropriate, given the potential influence of recent anthropogenic warming? Could using a pre-industrial baseline change the inferred SST anomalies?"*

----- In this study, the present baseline was used as 2000-2008 AD because

the Sr/Ca-SST calibration of modern Tahiti corals for comparison was established using the records for 2000-2008. As you pointed out, the annual SST for 2000-2008 (27.7±0.2 °C) is 0.7±0.4 °C higher than 1854-1950 (27.0±0.3 °C). Following the comment, we added the explanation "Taking account of the effects of recent global warming since 1950, our paleo-SST reconstructions should be corrected using the SST difference of 0.7 ± 0.4 °C between 2000-2008 and 1854-1950, as estimated from NOAA NCDC ERSST v5 data." in this paragraph [Line 233-235 of the revised manuscript with highlighted].

Comment (#1-30, Line 200-201) *"The Sr/Ca-SST calibration slope used is from modern Tahiti corals. Have you considered possible shifts in calibration slope for glacial period corals due to physiological or environmental differences?"*

----- Possible shifts in calibration slope for glacial period cannot be considered in this study because there are no published researches on glacial coral Sr/Ca-SST calibrations in Tahiti.

Comment (#1-31, Line 220-221) *"The application of LeGrande and Schmidt (2006)'s modern δ^{18}Osw–SSS relationship is common, but is there any evidence or modeling result suggesting this relationship may have changed during glacial periods?"*

----- There is no consensus about the salinity-d18Osw relationship during glacial periods. Some simulation studies show that the salinity-d18Osw relationship may have changed in the Atlantic Ocean during glacial periods (e.g., Wadley et al., 2002 QSR), but others show that no drastic changes occurred in the relationship (Roche et al., 2004 EPSL). Therefore, we used a widely-accepted relationship in the South Pacific (LeGrande and Schmidt, 2006) on the assumption that it has not changed throughout the glacial-interglacial periods. When a relationship for glacial periods would be established, our paleo-SSS estimates can be re-calculated.

Comment (#1-32, Line 221-223) *"How much of the 3–4 °C cooling estimate is due to the individual corrections (e.g., inter-lab offset, growth-rate adjustment, seawater Sr/Ca)?*

Can the relative contributions be quantified or discussed?"

----- The relative contributions of growth-rate adjustment and seawater Sr/Ca difference can be quantified to be 0% and 21-28% of 3-4 °C. The correction of inter-lab offset is not related to this contribution.

Comment (#1-33, Line 221-223) *"How do these coral-based estimates compare with other local or regional paleo-SST/SSS proxies (e.g., foraminifera Mg/Ca, alkenones) in the same time slices?"*

----- Paleo SST and SSS data from foraminifera Mg/Ca and alkenones in ocean sediments show average values for several decades to centuries, which can be understood as annual mean values. Therefore, annual mean values from coral-based estimates can be compared with the other proxy records.

Comment (#1-34, Line 229) *"Can you elaborate on the specific correction factors applied and the uncertainties associated with each? How were the time-weighted averages computed (e.g., did you apply any weighting based on coral age model confidence intervals or sample resolution)?"*

----- Following the comment, we added the explanations "For comparison, previously reported coral Sr/Ca values were corrected for inter-laboratory offsets relative to the average value of 8.901 mmol/mol for the JCp-1 standard (Knebel et al., 2024) as well as seawater Sr/Ca changes on glacial-interglacial timescales, and the time-weighted Sr/Ca averages ~~within respective intervals~~ for selected periods during which the U-Th ages of fossil corals are overlapped are estimated following previous studies (Chuang et al., 2023; Knebel et al., 2024)." in this paragraph [Line 272-276 of the revised manuscript with highlighted].

Comment (#1-35, Line 231-232) *"What is the uncertainty ('C) associated with the reconstructed SSTs for each period, considering analytical, calibration, and age model uncertainties?"*

----- Following the comment, we added the uncertainty "~~~~~2.7±0.2 °C lower" and "~~~~~1.0±0.3 °C lower" in this sentence [Line 277-278 of the revised

manuscript with highlighted].

Comment (#1-36, Line 234-237) *"Have you attempted to correlate SST with sea level data quantitatively, or is the comparison purely interpretive? Would plotting SST vs. RSL strengthen the climate-state argument?"*

----- Following the comment, we added the correlation "(r = 0.94, n = 3, p < 0.01)" in this sentence [Line 281 of the revised manuscript with highlighted].

Comment (#1-37, Line 237-240) *"Is the salinity conversion based on a local modern δ18Osw-SSS relationship? If so, please cite the calibration and clarify the assumed slope."*

----- Following the comment, we added the explanation "if a salinity-d18Osw relationship is applied (LeGrande and Schmidt, 2006)" in this sentence [Line 287-288 of the revised manuscript with highlighted].

Comment (#1-38, Line 252) *"Can you elaborate on the specific correction factors applied and the uncertainties associated with each? How were the time-weighted averages computed (e.g., did you apply any weighting based on coral age model confidence intervals or sample resolution)?"*

----- Following the comment, we added the explanations accordingly. The time-weighted averages were calculated for selected periods during which the U-Th ages of fossil corals are overlapped. We added the explanation in the Discussion [Line 274-275 of the revised manuscript with highlighted].

Comment (#1-39, Line 270) *"Are the SST differences reported here consistent with broader regional reconstructions from other South Pacific sites (e.g., Vostok, EPICA Dome C, or MD06-2986)"*

----- Yes, lower SST signals during 153-148 ka and 30 ka are also recorded at the sites Vostok (Petit et al., 1999 Nature), EPICA Dome C (Jouzel et al., 2007 Science), and MD06-2986 (Ronge et al., 2015 Paleoceanography). Following the comment, we added the explanations "...(Fig. 6B), harmonizing well with Antarctica ice core records at the sites Vostok (Petit et al., 1999), EPICA Dome C (Jouzel et al., 2007), and EDML (EPICA Community

Members, 2006)" [Line 284-285 of the revised manuscript with highlighted] and "...(Fig. 6C), consistent with benthic foraminiferal $\delta^{18}O$ records in the Tasman Sea west of New Zealand (43.5°S, Ronge et al., 2015)" [Line 328-329 of the revised manuscript with highlighted]. And, these papers were added in the References.

Comment (#1-40, Line 271) *"While the coral-derived SST anomaly is reported with an uncertainty (+/-1.1 'C), the foraminiferal and alkenone records are not. For consistency and better comparison across proxy types, could you report uncertainties for these other proxies as well?"*

----- Following the comment, we will add the explanations "~~2~~ 1.8 ± 0.6 °C in the WPWP and ~~4~~ 4.4 ± 0.5 °C" in this paragraph [Line 327 of the revised manuscript with highlighted].

Comment (#1-41, Line 271) *"How robust is the SST anomaly at 153–148 ka given the temporal spread and potential uncertainties in coral U-Th ages? Could there be variability within that interval?"*

----- Coral records show snapshots of reconstructed SST time series for selected several years. Considering the interannual and decadal climate variability, the actual SST anomaly during 153-148 ka is likely to be larger or smaller than our estimates in this study.

Comment (#1-42, Line 271-274) *"Have you considered or discussed the potential systematic differences between SST reconstructions from different proxies (Sr/Ca, Mg/Ca, alkenones)? For example, were corrections applied for seawater Mg/Ca changes in the foraminiferal records?"*

----- In previous studies, foraminiferal Mg/Ca-derived SSTs were estimated on the assumption of constant seawater Mg/Ca because residence time of Mg and Ca is much longer (>1,000,000 years) than the glacial-interglacial cycles. In this study, we referred the reconstructed SST values published in Medina-Elizalde and Lea (2005).

Comment (#1-43, Line 274) *"Did you consider ENSO or other interannual variability during the glacial periods, and how might this influence the interpretation of stronger zonal SST gradients?"*

----- Following the comment, we added the explanation "Paleoclimate records and simulations indicate less frequent and weaker ENSO variability during the LGM relative to the present (Ford et al., 2015; Thirumalai et al., 2024). A climate simulation suggests that the equatorial Pacific climate under glacial conditions is characterized by a contracted WPWP and stronger SST gradient together with a deeper mixed layer driven by a stronger Walker circulation (Thirumalai et al., 2024). These considerations can support our interpretation of SST gradients in the subtropical and the mid-latitude regions of the South Pacific." in this paragraph. [Line 336-340 of the revised manuscript with highlighted].

Comment (#1-44, Line 276) *"As the distinction between latitudinal and zonal SST gradients is somewhat ambiguous, could you clarify whether the observed differences are primarily driven by latitudinal (meridional) or zonal (longitudinal) gradients, or both. Could this be better supported with spatial SST maps?"*

----- Probably, both. However, more paleoclimate records and simulation studies are needed to clarify whether the primary driving factor is latitudinal or zonal gradients. Therefore, following the comments, we corrected the explanation "These lines of evidence for the stronger latitudinal and/or zonal SST gradients imply..." [Line 333 of the revised manuscript with highlighted].

Comment (#1-45, Line 279) *"Could you elaborate on how well the reconstructed SST gradients match the modeled zonal wind fields or SST gradients? Any specific model experiments used?"*

----- In this study, spatial SST distribution cannot be reconstructed and so we cannot compare directly our data with modeled results. Some climate simulation studies and ice core studies indicate pronounced latitudinal winds during glacial cold conditions (Lambert et al., 2008; Cao et al., 2019; Krätschmer et al., 2022). Here, we would like to say that our consideration on

subtropical to mid-latitude SST gradients is roughly consistent with these views. Therefore, we corrected the sentence to weaken our indication "..., which could be supported by..." [Line 334 of the revised manuscript with highlighted].

Comment (#1-46, Line 283-284) *"How were the uncertainties in seasonal Sr/Ca amplitudes calculated, and are they comparable across time intervals?"*

----- The uncertainties in seasonal Sr/Ca amplitudes are standard deviation (SD, 1σ). Following the comment, we corrected the sentence to "Our Tahiti coral Sr/Ca seasonality of 0.23±0.04 and 0.17±0.03 mmol/mol at 153–148 ka and 0.18±0.02 mmol/mol at 30 ka is larger than that previously reported for HS1 (0.13±0.01 mmol/mol), B-A (0.12±0.01 mmol/mol), and the present (0.14±0.01 mmol/mol) (Knebel et al., 2024) (Fig. 6B)." [Line 343-345 of the revised manuscript with highlighted] and added "SD", "CE", and "Uncertainties are at 1σ level" at Table 1 (see the revised Table 1).

Comment (#1-47, Line 290-292) *"Could additional hydrological proxies or isotope-enabled modeling help clarify the dominant processes responsible for δ^{18}Osw changes?"*

----- We cannot find other studies on seasonally-resolved d18Osw model simulation. As you know, sediment core records do not tell us summer and winter d18Osw values because of low data resolution (several decades/sample). Therefore, we cannot clarify the dominant processes in this study and so will correct the phrase "suggest" to "may suggest" [Line 351 of the revised manuscript with highlighted].

Comment (#1-48, Line 293) *"Consider reorganizing the paragraph beginning with "The SPCZ is a diagonal band..." for clarity—it introduces background information somewhat abruptly in the middle of result interpretation."*

----- Following the comment, we will add the explanation "...at that time, possibly associated with the SPCZ variability different from today" in the sentence immediately preceding this paragraph for clarity [Line 353 of the

revised manuscript with highlighted].

Comment (#1-49, Line 297-298) *"Could you clarify how they distinguish between large-scale atmospheric influences (like SPCZ shifts) and local oceanographic drivers? Are there model simulations or regional paleoclimate reconstructions that support the proposed SPCZ changes during MIS 6b and the last glacial period?"*

----- In this study, it is impossible to distinguish between atmospheric influences and local oceanographic drivers due to lack of paleoclimate proxies and model simulations at 153-148 ka and 30 ka. However, some climate simulation studies indicate pronounced lower SSTs in the Pacific and reduced ENSO variability during the LGM, which can support lower activity of the SPCZ. Following the comment, we added the explanation "This climatic interpretation could be supported by a simulation study suggesting that the WPWP contracted to the west and the SST gradient became stronger in the equatorial Pacific during the LGM (Thirumalai et al., 2024)" in this paragraph [Line 361-363 of the revised manuscript with highlighted].

Comment (#1-50, Line 301-303) *"The comparison with Knebel et al. (2024) and Asami et al. (2009) is valuable, but a more detailed discussion of methodological differences or coral site locations would help contextualize why the reconstructed seasonality is higher in this study."*

----- Following the comment, we added the explanation "The comparison of SST seasonality between the penultimate glacial and the YD period is significant because the fossil corals were collected from the same site (Tiarei) in Tahiti and analyzed by the same methodology." in this paragraph [Line 370-371 of the revised manuscript with highlighted].

Comment (#1-51, Line 303) *"Revise for clarity in "which was suggested to be resulted from..." → "which was suggested to result from.."*

----- Following the comment, we will correct it accordingly [Line 366 of the revised manuscript with highlighted].

Reply to the comments (Reviewer #2)

General Comments:

Comment (#2-1) *"This manuscript presents a highly significant study that reconstructs ocean environments during MIS 3 and MIS 6—periods for which paleoclimate records are particularly scarce—using high-precision geochemical analyses of fossil corals. The approach of employing well-preserved coral skeletons as archives of high-resolution climate information is appropriate and timely, and the dataset provides important insights into past oceanographic and climatic variability. I especially appreciate the careful attention the authors have paid to diagenetic screening and to the influence of coral growth rates on analytical resolution. This demonstrates that the study was conducted with great care and methodological rigor, which strengthens the reliability of the results.*

However, there are several areas where the manuscript can be improved for clarity. First, descriptions of some correction methods are incomplete or missing, which makes it difficult for readers to fully evaluate the robustness of the results. Second, the interpretations of SST and salinity variations occasionally appear overstated given the relatively short duration of the records analyzed. These sections would benefit from a more cautious discussion that explicitly considers the uncertainties involved. Another point concerns the discussion of seasonality. Since corals are among the very few archives that can resolve seasonal-scale variations, it would be highly valuable if the manuscript provided a more careful and detailed discussion of seasonality, including error estimates and an assessment of whether observed differences are statistically significant. Finally, while the manuscript includes a discussion of SPCZ migration, it would be strengthened by explicitly considering ITCZ and/or ENSO, and by situating the findings within the broader context of paleoclimate records and model studies. This would allow the results to be more effectively placed in a global climatic framework and would broaden the potential impact of the study. In summary, this is an important and promising manuscript that has the potential to make a substantial contribution to the field."

----- Thank you so much for providing positive comments. Following comments from you and the reviewer #1, we improved the manuscript by adding some explanations on the correction methods for paleo-SST and -SSS,

the discussion on SST seasonality, and the relation with the ITCZ and/or ENSO variability.

Major comment (#2-2) *"Correction methods:*

Some descriptions of correction methods are omitted or unclear (e.g., P6 L138–140, L142; P7 L163–165). These should be explicitly stated in the Methods section."

----- Regarding the effects of different resolution, we followed the method of Asami et al. (2020, GRL) clearly showing the evaluation. Following the comment, we added the explanations "..., by following the method of Asami et al. (2020). As a result, the difference can yield offsets of +0.08 ± 0.07 °C and −0.09 ± 0.06 °C in reconstructed annual minimum (= winter) and maximum (= summer) SSTs from fossil coral Sr/Ca records (Table S2). The offset in SST seasonality is estimated to be −0.18 ± 0.09 °C, which is much smaller than the amplitude (about 3−5 °C, see the discussion) of seasonal Sr/Ca-derived SST changes in the fossil coral records and analytical Sr/Ca error (< 0.5 °C)." [Line 155-159 of the revised manuscript with highlighted] and also added a supplementary Table (Table S2) representing the evaluation results in this study. Regarding coral growth effects, we will add a brief explanation "It is noted that the effects of coral growth on geochemical records should be carefully considered for paleo-temperature estimations (see Section 3.2)." in Method section [Line 209-210 of the revised manuscript with highlighted].

Major comment (#2-3) *"Interpretation of short records:*

The discussion of SST and salinity variations occasionally appears overstated given the relatively short duration of the analyzed intervals (e.g., 30 ka, 153 ka). The associated uncertainties should be clearly acknowledged. The record of 30 ka has only for 2 years and a half."

----- Following the comment, we corrected some explanations on the short coral records in the Discussion, by using weaker expressions such as "(may) indicate" and "(may) suggest". Furthermore, we added a cautionary note "It is noted that our corals provide snapshots of less than 10-year-long time series for selected glacial periods, and the actual SST estimates could be potentially

changed by interannual and decadal SST variability" in the Discussion [Line 252-253 of the revised manuscript with highlighted].

Major comment (#2-4) *"Seasonality analysis:*
Coral skeletons are valuable archives for reconstructing seasonal variability. However, the discussion of seasonality requires more careful treatment, including error estimates and evaluation of whether differences are statistically significant (e.g., P13 L4–L6, discussion of 148 ka and 153 ka records)."

----- Following the comment, we included respective errors to the seasonality estimates in the Discussion. For example, we corrected the sentence to "Our Tahiti coral Sr/Ca seasonality of 0.23±0.04 and 0.17±0.03 mmol/mol at 153–148 ka and 0.18±0.02 mmol/mol at 30 ka is larger than that previously reported for HS1 (0.13±0.01 mmol/mol), B-A (0.12±0.01 mmol/mol), and the present (0.14±0.01 mmol/mol) (Knebel et al., 2024) (Fig. 6B)." [Line 343-345 of the revised manuscript with highlighted] and also added "SD", "CE", and "Uncertainties are at 1σ level" at Table 1 (see the revised Table 1).

Major comment (#2-5) *"The relationship between SPCZ and ENSO:*
The discussion on SPCZ migration would benefit from integration with previous work on ITCZ and ENSO. Relevant references should be added, and the relationship between salinity front, ITCZ position, and ENSO should be clarified (e.g., P11 L250, P13 L278)."

----- Following the comment, we added some explanations with relevant previous studies in the Discussion as follows;

"It is noted that the salinity front could have changed on interannual and decadal timescales associated with thermal and hydrological variations due to the ENSO and the Pacific Decadal Oscillation (Delcroix and McPhaden, 2002; Gouriou and Delcroix, 2002; Delcroix et al., 2007)" in this paragraph [Line 299-301 of the revised manuscript with highlighted],

"This climatic interpretation could be supported by a simulation study suggesting that the WPWP contracted to the west and the SST gradient became stronger in the equatorial Pacific during the LGM (Thirumalai et al., 2024)" in this paragraph [Line 361-363 of the revised manuscript with

highlighted],

"Paleoclimate records and simulations indicate less frequent and weaker ENSO variability during the LGM relative to the present (Ford et al., 2015; Thirumalai et al., 2024). A climate simulation suggests that the equatorial Pacific climate under glacial conditions is characterized by a contracted WPWP and stronger SST gradient together with a deeper mixed layer driven by a stronger Walker circulation (Thirumalai et al., 2024). These considerations can support our interpretation of SST gradients in the subtropical and the mid-latitude regions of the South Pacific." in this paragraph [Line 335-340 of the revised manuscript with highlighted].

Specific comments

Comment (#2-6) *"Fig. 2: For 9B17R1 (50–55 cm), was age dating performed? If so, please indicate the ages in the figure; if not, provide a reason."*

----- We apologize for confusing you. To avoid misunderstanding for readers, we added the explanation "From the perspective of stratigraphic succession, the mean of these two ages is used as best estimate for the age of our last glacial coral because our sample is located between those two samples in the sediment core (Fig. 2)" in the method [Line 89-91 of the revised manuscript with highlighted].

Comment (#2-7) *"Fig. 3 and Supplement, Section 2.2 Mineral screening：Based on the XRD and SEM observations, you state that only well-preserved skeletal portions were used for analysis. My understanding is that the analyzed areas correspond only to the red-lined segments in Fig. 3. However, other portions also appear well preserved. For example, in 9D25R1_65–75 cm, Table S1 suggests that segments 1–8 are all well preserved, yet only segments 2–5 were analyzed. Similarly, for9D25R2_43–51 cm (segments 1–3) and 51–57 cm (segments 1–4), Table S1 indicates they are suitable for analysis. Beyond calcite content and the presence/absence of secondary aragonite cement noted in TableS1 and SEM observations, were there any additional criteria used to decide which portions were selected for analysis?"*

----- Thank you for your insightful comment. Following the comment, we

added the explanation "The geochemical profiles for the use of paleoclimate reconstructions (shown as the red-lined segments in Fig. 3) are actually shorter than the criteria based on the XRD analyses and SEM observations (Table S1) because inappropriate skeletal portions were additionally rejected due to irregular skeletal growth and/or randomly scattered aragonite cements at the micro-scale that were confirmed by results of stable isotope analyses" in the method section [Line 113-116 of the revised manuscript with highlighted].

Comment (#2-8) *"Fig. 4: Please clarify whether Sr/Ca data have been corrected for seawater Sr/Ca ratio (P10 L197–201). Also, in the caption, "Horizontal bars represent analytical errors" appears to be a typo; should this be "Vertical bars"?"*

----- Following the comment, we added the explanation "..., without any corrections for seawater chemistry variations and skeletal growth rate effects" in the caption of Fig. 4. Sorry, this is a typo. We corrected "Horizontal bars" to "Vertical bars" in the caption accordingly.

Comment (#2-9) *"P6 L138-140 : It is not clear how the averaging effects were specifically calculated."*

----- We followed the method of Asami et al. (2020, GRL) clearly showing the evaluation. Following the comment, we added the explanations "..., by following the method of Asami et al. (2020). As a result, the difference can yield offsets of +0.08 ± 0.07 °C and −0.09 ± 0.06 °C in reconstructed annual minimum (= winter) and maximum (= summer) SSTs from fossil coral Sr/Ca records (Table S2). The offset in SST seasonality is estimated to be −0.18 ± 0.09 °C, which is much smaller than the amplitude (about 3−5 °C, see the discussion) of seasonal Sr/Ca-derived SST changes in the fossil coral records and analytical Sr/Ca error (< 0.5 °C)." [Line 155-159 of the revised manuscript with highlighted] and also added a supplementary Table (Table S2) representing the evaluation results in this study.

Comment (#2-10) *"P6 L142 : Regarding "the offset in SST seasonality," is this offset* *corrected for in the subsequent discussion?"*

----- We apologize for confusing you. To avoid misunderstanding for readers, we added the explanation "..., and the slight difference was not used for correction in this study" int this sentence [Line 160-161 of the revised manuscript with highlighted].

Comment (#2-11) *"P7 L155–156: $\delta^{13}C$ is not discussed in the main text; either move it to the Supplement or add a brief summary in the main text."*

----- Following the comment, we added a brief summary on d13C in the main text "The interpretation of coral $\delta^{13}C$ on glacial-interglacial timescales is complex, as has been previously discussed for last deglacial GBR corals in ~~the context of~~ the global carbon cycle relating to changes in atmospheric CO_2, reef carbonate production, and decomposition of organic land carbon (Felis et al., 2022)." [Line 190-192 of the revised manuscript with highlighted].

Comment (#2-12) *"P7 L163–165: Coral growth rates are relatively low (<5 mm/yr). Please clarify whether potential vital effects on $\delta^{18}O$ were corrected, citing relevant studies (e.g., Hayashi et al., 2013, Hirabayashi et al., 2013)."*

----- Thank you so much for providing supportive information. In this study, we corrected the effects on d18O using the relationship of Felis et al. (2003). This relationship is similar to the two studies you suggested. Therefore, we added the explanations "... (Felis et al., 2003) that is similar to other studies (Hayashi et al., 2013; Hirabayashi et al., 2013)" in the discussion [Line 239-240 of the revised manuscript with highlighted]. The two papers were added in the References.

Comment (#2-13) *"P9 L193–195: This methodological description should be moved to the Methods section."*

----- Following the comment, we moved the sentence to the method section and corrected the sentence "For inter-laboratory comparison of Sr/Ca-derived SST records, Sr/Ca measurements from different laboratories were normalized by correcting the offset in the mean Sr/Ca value of the JCp-1

standard relative to the average value of 8.901 mmol/mol, which was measured with the five modern Tahiti *Porites* corals (Knebel et al., 2024).” [Line 144-146 of the revised manuscript with highlighted].

Comment (#2-14) *“P10 L215‑216: Since the 30 ka record covers only about 2.5 years, its treatment requires caution. For the 153 ka record, the Sr/Ca data suggest that during the 20‑30 mm interval, summer SSTs were comparable to those of 2000‑2008, indicating that temperatures were not necessarily 3–4 °C cooler than today. In particular, for the 153 ka Sr/Ca record, both the amplitude (i.e., seasonality) and the mean values appear to differ between 0–15 mm and 20–30 mm. I would encourage the authors to take special care in discussing this aspect.”*

----- Following the comments, we added the sentence “It is noted that our corals provide snapshots of less than 10-year-long time series for selected glacial periods, and the actual SST estimates could be potentially changed by interannual and decadal SST variability.” in this paragraph [Line 252-253 of the revised manuscript with highlighted].

Comment (#2-15) *“P13 L4-L6 : Regarding seasonality, what are the associated uncertainties for each record? Do the differences remain significant when errors are taken into account? Both the 153 ka and 148 ka records seem to include years where the seasonality is nearly identical to that of the modern record. For example, in the 148 ka record, the 0–20 mm interval appears to show reduced cyclicity compared to the 20–45 mm interval. Similarly, in the 153 ka record, especially within the 0–20 mm interval, the seasonality appears comparable to that of the modern record.”*

----- The uncertainties in seasonal Sr/Ca amplitudes are standard deviations (SD, 1σ) that was calculated for respective coral records. Following the comment, we corrected the sentence to “Our Tahiti coral Sr/Ca seasonality of 0.23±0.04 and 0.17±0.03 mmol/mol at 153–148 ka and 0.18±0.02 mmol/mol at 30 ka is larger than that previously reported for HS1 (0.13±0.01 mmol/mol), B-A (0.12±0.01 mmol/mol), and the present (0.14±0.01 mmol/mol) (Knebel et al., 2024) (Fig. 6B).” [Line 343-345 of the revised manuscript with highlighted] and also added “SD”, “CE”, and “Uncertainties are at 1σ level”

at Table 1 (see the revised Table 1).

Comment (#2-16) *"P7 L163–165 : The coral skeletal extension rates are relatively low (<5 mm/yr). Could the influence of δ¹⁸O vital effects be an issue in this case (e.g., Gagan et al., Inoue et al., Hayashi et al., Hirabayashi et al.)? If acorrection has been applied, it would be helpful to briefly describe the method in the Materials and Methods section."*

----- We corrected the effect and added the explanation "...and for the $d^{18}O$ offset caused by difference in annual growth rate between modern and fossil corals using a previously established equation with an r2 value of 0.91 for eleven *Porites* spp. corals with growth rate of 2.0–15.2 mm/year (Felis et al., 2003), which is similar to other studies (Hayashi et al., 2013; Hirabayashi et al., 2013). In contrast, coral Sr/Ca data is not corrected for the Sr/Ca offset caused by differences in annual growth rate because there is no significant relationship between coral Sr/Ca and growth rates (Inoue et al., 2007; Hirabayashi et al., 2013)." [Line 237-242 of the revised manuscript with highlighted].

Comment (#2-17) *"L200–201 & L205–206: Slopes of Sr/Ca–SST and $\delta^{18}O$–SST conversion equations are given, but the associated uncertainties are not. Please estimate how these propagate into reconstructed SST and SSS."*

----- The uncertainties of these equations were included for SST and d18Osw estimations. Following the comment, we corrected the descriptions to "...of -0.050 ± 0.002 mmol/mol/°C..." and "...of -0.20 ± 0.02 ‰/°C..." in respective sentences [Line 162, 164, 233, 243, and 317 of the revised manuscript with highlighted].

Comment (#2-18) *"The Discussion focuses on SPCZ displacement — is it possible to also discuss contemporaneous changes in the ITCZ and ENSO? In the Conclusion the authors note that longer coral records would be needed to discuss ENSO; however, are there existing paleoclimate records or model studies that currently allow discussion of ENSO or ITCZ behavior for these time intervals? If so, please cite and discuss those prior findings (from proxy records and/or model simulations) and clarify whether they support* *or contradict the SPCZ-centered interpretation."*

----- Unfortunately, we cannot discuss contemporaneous changes in the ITCZ and ENSO because there existing no coral records and model studies on these behaviors at 153-148 ka and 30 ka. However, some paleoclimate records and simulations indicate less frequent and weaker ENSO variability during the LGM relative to the present (e.g., Ford et al., 2015 Science; Thirumalai et al., 2024 Nature). A recent climate simulation suggests that the equatorial Pacific climate under glacial conditions (LGM) is characterized by a contracted WPWP and stronger SST gradient together with a deeper mixed layer driven by a stronger Walker circulation (Thirumalai et al., 2024), which could support our interpretation on the SPCZ displacement. Following the comment, we added the explanations in the Discussion "Paleoclimate records and simulations indicate less frequent and weaker ENSO variability during the LGM relative to the present (Ford et al., 2015; Thirumalai et al., 2024). A climate simulation suggests that the equatorial Pacific climate under glacial conditions is characterized by a contracted WPWP and stronger SST gradient together with a deeper mixed layer driven by a stronger Walker circulation (Thirumalai et al., 2024). These considerations can support our interpretation of SST gradients in the subtropical and the mid-latitude regions of the South Pacific." [Line 336-340 of the revised manuscript with highlighted].

Comment (#2-19) *"P11 L250 — The salinity front: how is this feature related to ITCZ position and to ENSO variability?"*

----- Following the comment, we added the sentence "It is noted that the salinity front could have changed on interannual and decadal timescales associated with thermal and hydrological variations due to the ENSO and the Pacific Decadal Oscillation (Delcroix and McPhaden, 2002; Gouriou and Delcroix, 2002; Delcroix et al., 2007)." in this paragraph [Line 299-301 of the revised manuscript with highlighted].

Comment (#2-20) *"P13 L278 — The "stronger zonal SST gradient": can this be interpreted as being related to ENSO variability?"*

----- Yes, as you pointed out, we also think that is a possibility. So, we added the explanation "Paleoclimate records and simulations indicate less frequent and weaker ENSO variability during the LGM relative to the present (Ford et al., 2015; Thirumalai et al., 2024). A climate simulation suggests that the equatorial Pacific climate under glacial conditions is characterized by a contracted WPWP and stronger SST gradient together with a deeper mixed layer driven by a stronger Walker circulation (Thirumalai et al., 2024). These considerations can support our interpretation of SST gradients in the subtropical and the mid-latitude regions of the South Pacific." in this paragraph [Line 336-340 of the revised manuscript with highlighted].