Interactive comment on "Evidence of intense climate variation and reduced ENSO activity from $\delta^{18}O$ of *Tridacna* 3700 years ago" *by Yue Hu et al.*

Anonymous Reviewer #2:
We would like to thank this reviewer for her/his careful reading on our manuscript. Please find our detailed answers to each comment below. The reviewer comments are in normal black script, our answers are in blue italics and the revised texts are in blue normal script.

General Comments:

Hu et al. present a new oxygen stable isotope record of a fossil giant clam from the South China Sea, which reveals new high resolution insights into the ENSO activity dated back 3700 yr BP and fine-tuned using a modern Tridacna for comparison. As this study fits well into the journal's scope I rate this manuscript to be of high interest to the audience of Climate of the Past and encourage publication after minor revision. As the study was carried out on only one specimen it has a "case study-like" read, however, the authors convince me that their application bears high potential for a potential larger-scale study with more specimens. The manuscript is well structured and outlined. The methodological part appears sound, which is apparent when e.g. sampling resolutions are discussed. I feel the introduction could benefit from discussing and citing more sclerochronological papers discussing oxygen stable isotope records from bivalves (they don't have to relate to the sampling site) and I would strongly argue that a recent paper demonstrating shell architecture of Tridacna ought to be mentioned and cited (Agbaje et al.2017). Further, I have some comments to the title (see below) and there are a few other (mostly language) issues that I feel need fixing before moving forwards and I provide a list of more detailed comments below to address these. I enjoyed reading this study and hope the authors will find my suggestions helpful and encouraging!

We thank the reviewer for his/her positive evaluation of our manuscript, and the detailed comments he/she suggested are really helpful. We have checked those errors to improve our manuscript and answered the questions in detail below.

Specific comments:

L1-2: I believe the use of "ENSO" in the title is not wise. Titles should be fully understandable to a broad audience and community-specific abbreviations should be avoided. I'd urge the authors to type out "ENSO" or phrase this differently. Also it may be good to use "Giant Clam" instead of "Tridacna" in the title.

Thank you for your suggestion, we have corrected them.

L22: “are the largest marine bivalves” and “carbonaceous shell” and “can be used for high-resolution paleoclimate reconstructions”.

Done.

L47: delete “of”.

Done.

L48: “physicochemical” is weird in this context – do you want to record environmental signatures encoded within the biocarbonate or do you want to look at physiological variations that may or may not be influences by external factors?

We have rewrote this expression. Here, we refer to both environmental records by biochemistry ($\delta^{18}O$) and ontogenetic change (e.g. daily increment with dark/light couples) in Tridacna. “physicochemical” has been replaced by “biochemical and ontogenetic”.

L49: “on past climate dynamics” delete “the”.

Done.

L50-51: I recommend also citing the most recent work on the crossed-lamellar shell architecture of Tridacna see reference: Agbaje, O. B. A., R. Wirth, L. F. G. Morales, K. Shirai, M. Kosnik, T. Watanabe, and D. E. Jacob. "Architecture of crossed-lamellar bivalve shells: the southern giant clam (Tridacna derasa, Röding, 1798)." Royal Society open science 4, no. 9 (2017): 170622.

Done.

L54: I doubt that Tridacna lives up to “few centuries” where is the evidence (reference)? This may have been mixed up with Arctica shells or other long-lived bivalves but these are very different from Tridacna!

*We apologies for having made a mistake in the text and have changed the expression to “*from several decades to about a hundred year*”. Some people in China said they had found an about 200 years old Tridacna gigas, but it has not been confirmed by authorities. From the Tridacna gigas we collected, the oldest one had lived about 100 years, most of them are between 30 to 60 years.*

L57: “precipitate” is really a wrong term when talking about shells as it is closely associated with classical crystallisation pathways (i.e. “inorganic” systems). However,

we know for more than over a decade now that shells form by non-classical crystallization pathways via precursor phases (amorphous calcium carbonate and/or vaterite). I am not saying you need to venture into the area of shell biomineralization here but I would strongly argue to find a better word for this text passage. Maybe replacing "precipitate their shells" with simply "grow".

We accept the referee's suggestion, and have replaced the word "precipitate" into "grow".

L59-60: What do you mean with "ontogenetic reduction"?

"ontogenic reduction" refers to the decreasing growth rate with ontogeny. This word was mentioned by K. Welsh (2011). As K. Welsh indicated in his article, the ontogenic reduction in growth of T. gigas does not reduce the reliability with which temperature and $\delta^{18}O_w$ variability can be reconstructed. Climate reconstruction in $\delta^{18}O_{shell}$ don't have an incongruity with temperature and $\delta^{18}O_w$ which might be an obviously declined or increased tendency. We have rephrased this sentence to make this clearer:
and the reliability in reconstruction between temperature and $\delta^{18}O_w$ variability would not be reduced by the ontogenic reduction in growth of the *Tridacna* $\delta^{18}O$.

L80: "occurring nowadays", however, I think you should try and find a more appropriate word than "nowadays" as this sounds perhaps too casual and please replace throughout manuscript.

As suggested by the reviewer, we have replaced the word "nowadays" into "recent decades" or "present".

L83-84: Better: "High-resolution isotopic geochemical data from Tridacna may provide detailed insight into climatic variations of this period."

Done.

L117: "give distinct seasonal SST to the Tridacna from the coral reefs" reads clumsy, perhaps change to "provide distinct seasonal SST for Tridacna populating the coral reefs of the Xisha Islands".

Done

L123-125: I don't understand "rehandling" do you mean "re-sampling"? I agree with referee 1 that this sentence needs to be rewritten for more clarity. Please change throughout the manuscript.

Thanks for the suggestion. We agree with you that change the verb "rehandle" into "resample" will be better. The technique we used for the resampling is a cubic spline

model in AnalySeries 2.0.8. This method was first applied by Schöne and Fiebig (2009), who used bivalve shells (Arctica islandica) to reconstruct climate. They suggested that 7 points per month would elapse during the core growing season of the shell (i.e., time interval of fastest shell growth covering the seasonal extremes). And only the annual sample number for which equal to or more than seven existed could be used. Therefore, we used 7 points per month.

L130-131: Perhaps better: "It is excluded that river runoff effects SSS as the Xisha Islands are at a XXX km distance to the continental mainland." Please quantify roughly to provide evidence.

Done.

L138-143: I recommend providing a sentence regarding the crossed-lamellar shell architecture of Tridacna see above mentioned reference Agbaje et al. (2017).

We thank the referee for his/her advice and have added them in the manuscript as follow:
Study in shell architecture showed a crossed lamellar microstructure with a strong fibre texture made the mechanical properties of those bivalve shells more optimized (Agbaje et al., 2017).

L144: when you mention "^{14}C AMS" for the first time I recommend providing the full method name in brackets (replace "^{14}C AMS" with "^{14}C AMS (Accelerator Mass Spectrometry)") for readers that lack this methodological background.

Done.

L145: I don't understand the meaning of "conventional" in this sentence – maybe not the right phrase? What is the uncertainty? First or second standard deviation or something else?

From the modern Tridacna samples we collected in this area, the dating results showed no obvious "reservoir effect" (Liu et al., 2019). Tridacna might exchange its carbon with the atmosphere through photosynthesis. Therefore, we used the atmospheric ^{14}C yield model to calibrated. We have clarified the details about the radiocarbon date calibration as followed:
The radiocarbon age determination was performed at Institute of Earth Environment of Chinese Academy of Sciences. The ^{14}C Accelerator Mass Spectrometry data revealed the fossil *Tridacna gigas* age was 3437 ± 28 yr BP. Due to no obvious "reservoir effect" in dating results of modern *Tridacna* shells, the atmospheric ^{14}C yield model was used to calibration. The calibrated date (2σ) was range from 1783 to 1663 cal BC, with the median date is 1741 cal BC by using the IntCal13 of Radiocarbon Calibration Program CALIB 7.10.

L154: “from adult to childhood” is not the right phrase how about “in a transect from adult to ontogenetically younger shell”?

Thank you for your advice, we have replaced this phrase.

L185: “40 dark/light couples (each representing one year)” please explain how dark/light line couples relate to time/tide schedules/seasonality. How much time/which tide pattern does one dark-light line couple stand for?

We have added them to clarify as follow:
From the shell slice section, dark/light line couples (each couple represents one year) can be seen clearly (Fig. 1c, Fig. 3a). Follow the $\delta^{18}O_{A5}$ profiles, those short and dark lines (transparent) corresponding to higher $\delta^{18}O_{A5}$ values, which means *Tridacna* grew in low temperature (cold seasons such as December to February). In contrast, lower $\delta^{18}O_{A5}$ values lie in the long and light lines (opaque), corresponding to the high temperatures (warm seasons such as March to November).

L192: Increments are not obvious to me from the image. Especially Fig. 3b is not clear what one should see, perhaps choose a different image with better resolution.

It’s really hard to take a clear picture from Tridacna A5 for the organic matter influence. Those organic matter covered most of increments and make those increments unclear. We had tried our best to find this picture under microscope with obvious increments change. We have retreated the picture contrast and brightness to make them clear as the reviewer’s suggestion.

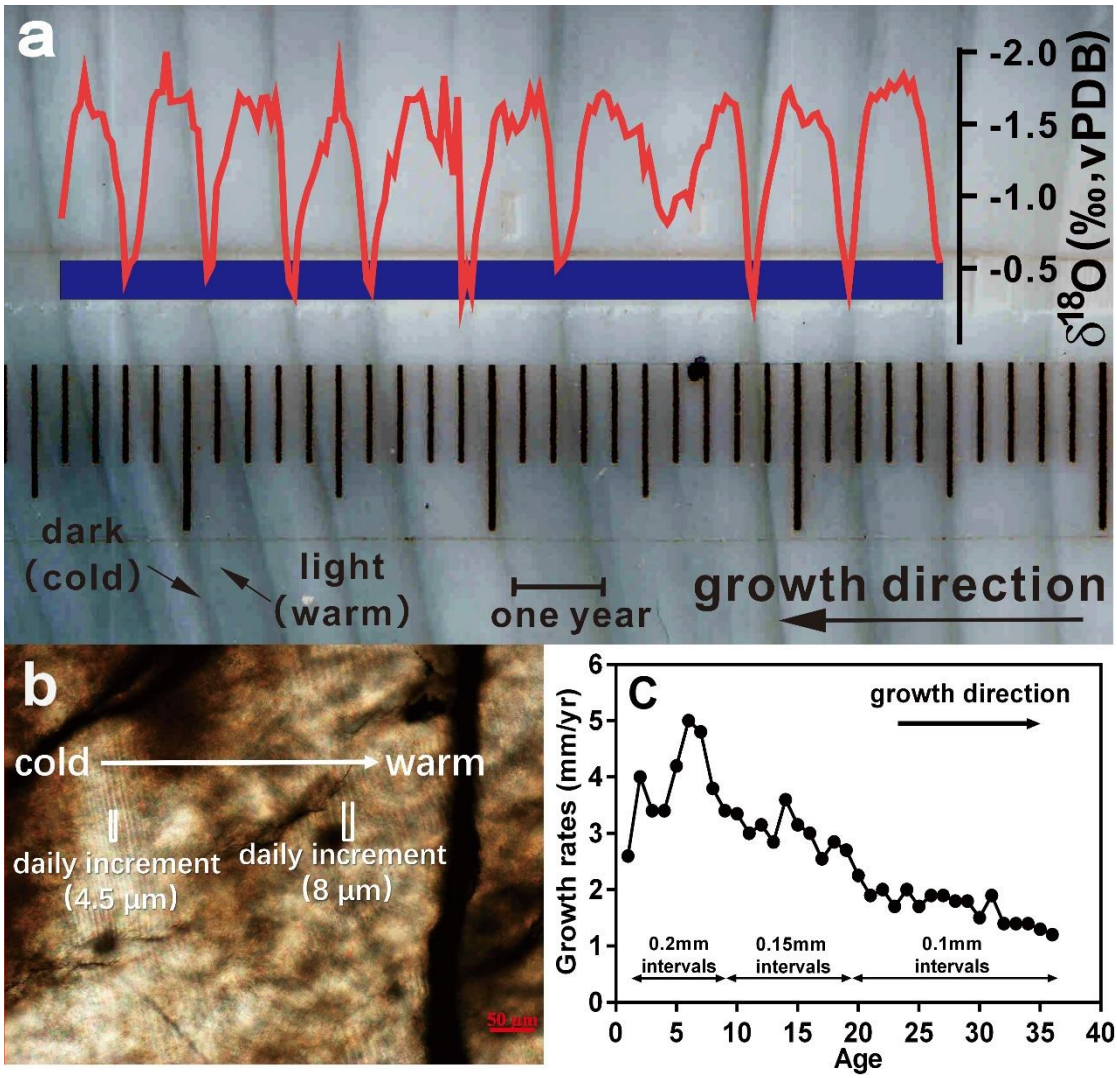

Figure 3. (a) Dark/light lines consistent with $\delta^{18}O_{A5}$ profiles. Dark and light lines correspond to high $\delta^{18}O$ (cold seasons) and low $\delta^{18}O$ (warm seasons), respectively. The distance between the dash lines represents a year that *Tridacna* grew. Blue line represents the sampling line. (b) Under the microscope, daily increments (a dark coupled with a light increment) grow slower when seasons are cold, but faster when the temperature rises up. (c) Growth rates (line 2 in Fig. 1c) in fossil *Tridacna* A5.

L192-193: "In general, Tridacna A5 grew faster in warm seasons and slower in cold seasons (Fig. 3b)." Where is your evidence for this assumption? I feel you need to back this up as this varies between species and you need to demonstrate to the reader that it is the case for Tridacna. Also, more seasonal information may be needed to achieve this. How long are summers how long are winters? For example: if a reader believes summer and winter are similar in length one could misinterpret short low $\delta^{18}O$ periods may have just been formed quicker (and have thus higher not lower growth rates!). This all needs more explanation and demonstration and is important as you build upon this later in the discussion. Perhaps see other papers I suggest any study by Carré et al as they are very educative in this respect.

This evidence focuses on Fig. 3b and we added more clarification in section 2.4. As we mentioned above, it's hard to see entirely increments in a year because of the organic matter influence. However, some fragments near the highest $\delta^{18}O_{shell}$ (indicating this period happened in cold season) show the increments change as the $\delta^{18}O_{shell}$ become lower (temperature become higher). From Fig. 3b, the daily increment is about 2.7 μm in low temperature, while as the temperature rises up, the daily increment can reach to 5.7 μm. It happened normally throughout Tridacna's life. Therefore, we have this conclusion that Tridacna grew faster in warm seasons and slower in cold seasons. Meteorological observations reveal that the cold seasons happened from about December to February, the rest of months are relatively suitable for Tridacna to grow fast. But it's hard to distinguish exactly how long is cold and how long is warm through Tridacna's increments. The growth rates influence on $\delta^{18}O_{shell}$ cannot be eliminated. However, we use the resampling method suggested by Schöne and Fiebig (2009), which try to reduce this problem as much as possible.

L196-197: I don't understand this sentence.

As suggested by Schöne and Fiebig (2009), the technique we used for the resampling that would elapse during the core growing season of shell (i.e., time interval of fastest shell growth covering the seasonal extremes). Also, before we resample the data, the numbers of annual data change because of different growth rates. To some extent, data resampling makes annual data become comparable.

L201: Perhaps not everything about Tridacna but $\delta^{18}O$?

You are right, we have changed this phrase into "oxygen isotopic equilibrium".

L259: "lived 3700 years ago" delete "in".

Done.

L286-287: Better: "Due to a higher sampling density in Tridacna: : :".

Done.

L288: "magnified" is the wrong word here.

Thank you. We have replaced the word into "enlarged".

L292: "switching" wrong word, replace throughout manuscript.

Thank you. We have replaced the word into "transition".

L293-294: This sentence contradicts itself and needs rewording for clarity.

The seasonality is the range between the lowest temperature and the highest temperature in the text. In order to eliminate the different influence in location, we use the reconstructed SST_{A5} and North Reef SST (from NOAA) to compare and the result shows the seasonality in 3700 years ago had slightly lower. Besides, the transition between cold to warm seasons focuses on the slope of $\delta^{18}O_{shell}$ when temperature change from low to high (or high to low), mainly focus on 1st r-month to 2nd r-month (or 6th r-month to 7th r-month). This situation is better to compare between two $\delta^{18}O_{shell}$ (modern and fossil) because the monthly data are not equal to evenly instrumental data. Therefore, we can see in Fig. 4c, the slope of A5 is obviously sharper than YX1, which means the transition between cold to warm seasons was more serious 3700 years ago. In conclusion, we consider that the climate around 3700 years ago had slightly lower seasonality than present, and the transition between cold to warm seasons was more serious.

L296-299: reads more like an introduction section and is not relevant here (suggest to delete).

As suggested by both two reviewers, we have removed this section.

L303: "instrumentation data" is odd.

Thank you. We have replaced the word into "modern instrumental data".

L326: "calcite-affected" sounds also a bit odd to me maybe you can find a better term. Why is calcite "bad" in this sense? Why is it a limitation?

*We apologize for this confusion in the text. We have replaced this sentence into "*such as those concerning the post-depositional diagenetic alteration between aragonite and calcite*". As McGregor and Gagan (2003) indicated in their research, some corals had both aragonite and calcite in their skeleton, the range between them in $\delta^{18}O$ could reach to nearly 3‰. Such alteration should be paid more attention before we use for accurate paleoclimate reconstructions.*

L326-328: Better perhaps: "Analyses of Tridacna species are performed to overcome this limitation by taking advantage of their denser shells, negligible diagenetic alteration, and oxygen isotopic equilibrium with seawater."

Done.

L338: unclear.

Do you mean that there is an unclear about which one we bring 3-month forward? We added this for clarification:

According to the SST series, the North Reef SST have a 3-month time lag behind the Ninõ 1 + 2 SST (Fig. 8a), and thus we bring 3-month of the North Reef SST forward to eliminate the lag.

Figure 1: It looks like your 5 cm scale bar is too large for the scale in the figure (measuring tape, here 5 cm look smaller). There are some grammar issues in the figure caption.

We apologize for having made this mistake in the scale bar and have replaced the right one. Figure caption had rewritten as follow:

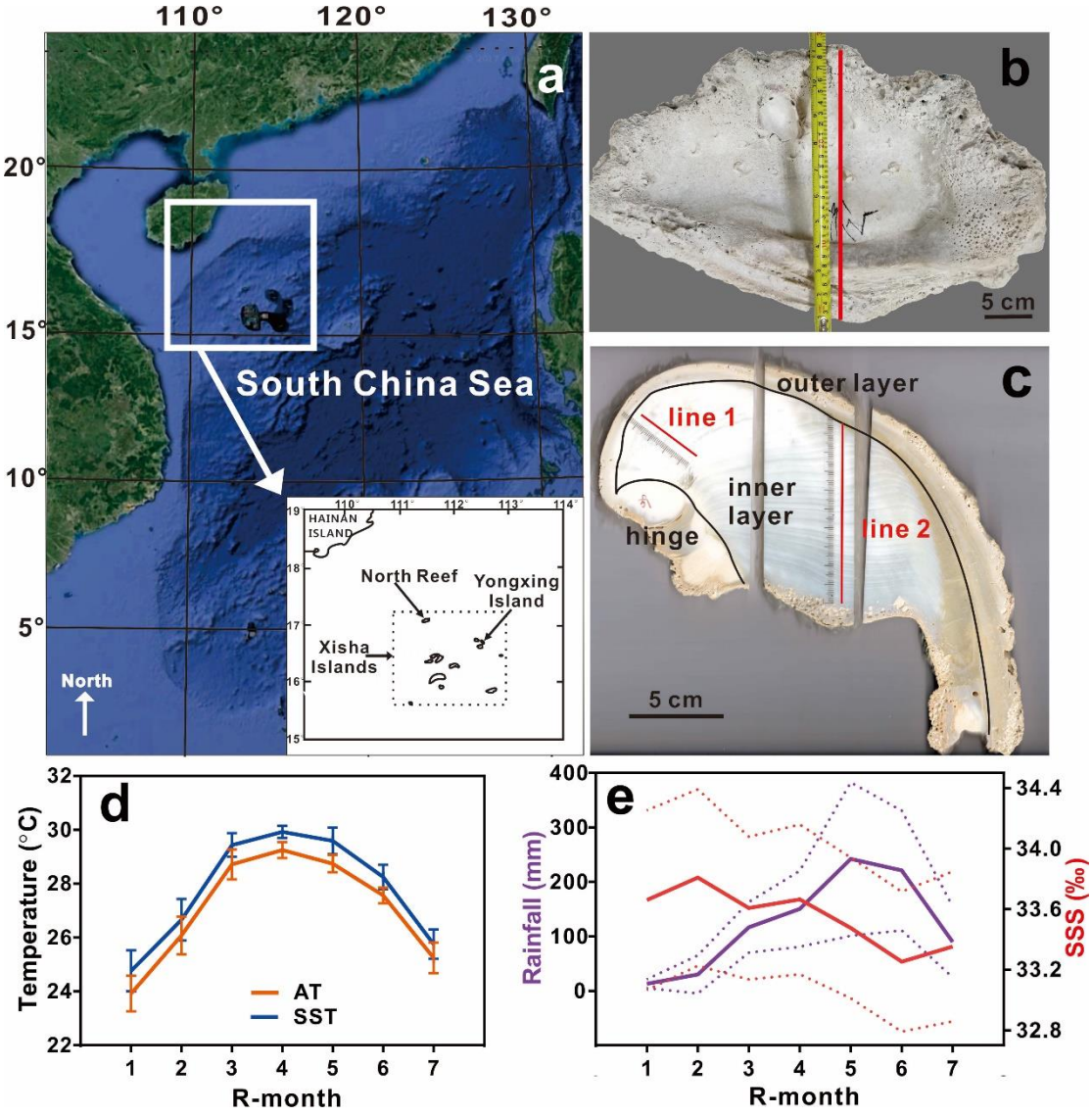

Figure 1. (a) Maps of the South China Sea, with the location of the sample study area in the Xisha Islands. (b) Photo of integral *Tridacna* A5, a slice was cut from the red line of integral *Tridacna* A5. (c) Different parts can be seen (hinge, inner layer, and outer layer), the red lines are the sampling lines for $\delta^{18}O$ analysis. (d) Meteorological observations in the Xisha Islands from 1994 to 2005: R-monthly average air temperature (AT) and sea surface temperature (SST), the error bars reveal the highest

and the lowest temperature in the month; (e) R-monthly average rainfall and sea surface salinity (SSS) with standard deviation (1σ).

L633: “amplitude” may not be the right word here.

We have removed this word and rewroted this sentence.

L635-636: “under the microscope, daily increments grow slower in cold seasons, but faster in warm seasons” – this is not visible from microscope images alone! This needs more explanation! Also, image is not really easy to understand (what should be seen? It’s all very blurry).

As suggested by the reviewer, we have replaced the photo of Fig. 3b and added for more clarification in the 2nd paragraph of section 3.2:
Furthermore, daily increments (a dark coupled with a light increment) can be seen under the microscope (Fig. 3b). Here, a fragment was chosen where $\delta^{18}O$ was near highest in a year. This period lied on the cold season which daily increment was about 2.7 μm. When the temperature rose up as warm season began, *Tridacna* grew faster that daily increment could reach to 5.7 μm. This situation occurred throughout *Tridacna*’s life. In general, *Tridacna* A5 grew faster in warm seasons and slower in cold seasons.

Reference

Schöne, B. R. and Fiebig, J.: Seasonality in the North Sea during the Allerød and Late Medieval Climate Optimum using bivalve sclerochronology, Int. J. Earth Sci., 98(1), 83–98, doi:10.1007/s00531-008-0363-7, 2009.

McGregor, H. V. and Gagan, M. K.: Diagenesis and geochemistry of Porites corals from Papua New Guinea: Implications for paleoclimate reconstruction, Geochim. Cosmochim. Acta, 67(12), 2147–2156, doi:10.1007/430_2015_174, 2003.

Welsh, K., Elliot, M., Tudhope, A., Ayling, B. and Chappell, J.: Giant bivalves (*Tridacna gigas*) as recorders of ENSO variability, Earth Planet. Sci. Lett., 307(3–4), 266–270, doi:10.1016/j.epsl.2011.05.032, 2011.

Liu, C., Yan, H., Fei, H., Ma, X., Zhang, W. and Shi, G.: Journal of Asian Earth Sciences Temperature seasonality and ENSO variability in the northern South China Sea during the Medieval Climate Anomaly interval derived from the Sr / Ca ratios of *Tridacna* shell, J. Asian Earth Sci., 180(June), 1-9, doi:10.1016/j.jseaes.2019.103880, 2019.