

Clim. Past Discuss., referee comment RC1
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Comment on cp-2021-120

Anonymous Referee #1

Referee comment on "A 334-year coral record of surface temperature and salinity variability in the greater Agulhas Current region" by Jens Zinke et al., Clim. Past Discuss., <https://doi.org/10.5194/cp-2021-120-RC1>, 2021

General Comments

The manuscript by Zinke et al. presents an annual coral Sr/Ca record from the southwestern Indian Ocean that complements previously published d18O records from the same coral. The authors use these records together to reconstruct changes in both SST and d18Osw since the Little Ice Age, offering one of the longest paired coral records for this ocean region. The location of the coral site allows the authors to examine past changes in the Agulhas current region, and the extent of Pacific climate influences in the southwest Indian Ocean, filling in crucial gaps in our understanding of Indian Ocean variability. However, the low-resolution (annual) sampling of the Sr/Ca record and the low correlation of the annual Sr/Ca-SST relationship ($r < 0.43$) limit the paired records at this coral site. The model simulations used in this study also do not directly serve as a validation that the Sr/Ca and d18Osw records represent regional variability, given that no significant relationships were found between a) the model SST or SSS simulations and the coral records themselves, and b) the SSS simulation and observational SSS throughout the region. It may help to re-frame the model results as a focus on the spatial patterns of the model compared to observations, focusing on the broad-scale temperature patterns. Lastly, this manuscript would benefit from a more detailed discussion of the interannual to multi-decadal Pacific Ocean signals that reach the coral site. The manuscript currently examines links to ENSO and the possible mechanisms by which ENSO signals reach the southwest Indian Ocean. However, there is limited discussion of the implications for the changes in the variability recorded by the coral through time in terms of ENSO strength, or changes in ocean advection. Adding this discussion in would help highlight the importance of such a record for understanding past changes in climate in the southwest Indian Ocean region.

Specific Comments

This manuscript would benefit from higher resolution Sr/Ca analysis that would allow for a higher resolution calibration and reconstruction that matches the resolution of the d18O record from the same coral. There does not seem to be a justification given as to why Sr/Ca was sampled and analyzed at annual resolution, but the authors point out that the low resolution of the Sr/Ca record may be the cause of some of the poor agreement in their comparisons (e.g., lines 336-340). The strongest Sr/Ca-SST calibration for the coral site has an r value of 0.43 (with Had3), which would be an r^2 value of only 0.18. Though this relationship is significant, the low correlation suggests that annual Sr/Ca may not be capturing the annual SST signal at the coral site very well.

One example of the potential for the Sr/Ca-SST relationship to be hindering the SST reconstructions is found in lines 223-224. Here, I don't see that d18Osw reconstructed from HadISST and Sr/Ca overall co-vary at interannual timescales. Figure S2b shows quite a lot of mismatches from year-to-year. It seems that at times the lower-frequency patterns match fairly well, as the authors pointed out the most depleted values occurring in the late 1800s. However, the low-frequency patterns are not well captured from the 1900s-1950s where the d18Osw reconstruction from Sr/Ca shows a period of enrichment not resolved in the d18Osw reconstruction from HadISST. It may help to clarify exactly what the authors are pointing out here, with more specific references to periods and timescales of co-variance.

In addition to the Sr/Ca aspects, this manuscript would benefit from a more detailed presentation of the model results. The authors establish well that the model internally shows robust SST and SSS comparisons between the Ifaty and AC regions, drawing a link to the broader regional patterns that the Ifaty coral should represent. However, few specific details in terms of the comparison of the model simulations to observations and the coral proxy records are included, making it difficult to understand how well the model simulations correspond with the observed and reconstructed variability at Ifaty and within the broader AC region. For example, in line 246 the authors write that simulated SST is "significantly correlated between the simulation and all data products", but the specific data products, the spatial domains used and the time periods compared are unclear. Are these comparisons of the Ifaty coral site, the AC region or the southwest Indian Ocean more broadly? Figure 4a clarifies some of these questions, but these details would be helpful in the main text, as well as in the Figure 4 caption. In addition, the authors note that neither the model simulations nor data products are correlated with the coral record, calling into question whether the model simulations are resolving the same variability as is in the coral reconstruction. This seems to contradict the aim of using these model simulations to validate that Sr/Ca and d18Osw represent temperature and salinity for the broader AC region (line 231). The model results do not seem to support this objective, and it may make more sense for the authors to re-frame this section of the manuscript to better highlight what the model is able to show well.

The authors should also provide a more detailed discussion of the implications of this record in terms of understanding past changes in ENSO, the IOD or climate-driven ocean advection from the Pacific Ocean. At present, the authors characterize the features resolved in the coral record and highlight how these may partly be related to ENSO. However, the authors have a remarkably long record of southwestern Indian Ocean variability, so a larger discussion of what we can learn from changes in the variability over the past four hundred years in terms of ENSO strength, or changes in ocean advection would better emphasize the importance and strength of the coral record being presented.

In addition, the authors point out that while ENSO plays a role, there are other climate modes that are likely impacting their record, such as the IOD or PDO. Given the importance of these climate modes in the region as indicated by previous publications, it seems crucial to include evaluations of the role that the IOD and/or PDO play in influencing their coral record throughout the manuscript.

Lastly, I don't think that the inter-colony comparisons discussed in lines 317-322 of the manuscript overall support the authors' conclusion that the sites show comparable temporal changes. I suggest that the authors revisit this section and more clearly explain where and how strongly the records agree, and where they don't. There may be opportunities for interesting discussions surrounding the change in the relationships between these coral records/sites through time. For example, the Mayotte and Ifaty $\delta^{18}O_{sw}$ records do not appear to consistently agree on interannual timescales. Figure 10a shows mismatches in the records that are not just in the early 20th century, for example the 1960s-1970s and 1930s-1940s. It's also unclear whether the relationship between the Mayotte and Ifaty $\delta^{18}O_{sw}$ records is significant as no statistical information was provided. In addition, while the correlation between Antongil Bay and Mayotte is significant, there is no indication here that the Antongil Bay record is significantly correlated with the Ifaty record presented in this manuscript. The authors state that the "variability range overlaps", but it is unclear exactly what is meant by this. The same issue is true for the comparison of La Reunion with the Ifaty record, where the authors state that the records overlap in terms of the interannual $\delta^{18}O_{sw}$ variability, but Figure 10c indicates poor agreement and no correlation is provided. It thus does not seem that there are overall comparable temporal changes across these records given that none of the other coral records seems to agree with the Ifaty record. In line 435, the authors instead suggest that comparable trends exist between the records due to the large uncertainties in the record, which may be what the authors intended to say with "variability range overlaps." More directly discussing the degree of uncertainty may be a better way to frame this comparison, particularly since the similarities are most evident in the long-term trends and low-frequency variability, and not in the interannual comparisons.

Technical Corrections

Line 174: change "Tab. S1" to "Tab. S2"

Line 184/185: Are these the exact GPS coordinates for the coral sites? More detailed GPS/site location information would be useful. In addition, the specific grid box coordinates used would be useful.

Lines 191-192: Why was the MEI index used instead of the SOI or Niño3.4?

Lines 202-203: It is difficult to assess how well the Sr/Ca record co-varies with AC ERSST in Figure 2a given that the timeseries are both very small, and the red line is extremely difficult to see. From what I can tell, it seems that there are mismatches throughout that are in addition to differences in amplitude (for example from 1900-1950). Modifying the figure to make the comparison easier would help to clarify these issues.

Line 203-204: I'm having a hard time understanding "and vice versa for cooler mean SST in Sr/Ca-SST" given that in the first part of the sentence you are discussing "lower mean SST in Sr/Ca-SST." How are these two points different?

Line 207: What are the slopes for each of the calibration equations presented in table S1? This information is an important aspect of evaluating the Sr/Ca- and d18O-SST relationships and should be included.

Lines 215-217: the equations used to reconstruct d18Osw should be presented at a minimum in the supplementary text.

Lines 228-230: I'm having a hard time understanding this sentence. Figure S4 seems to show a long-term warming trend since 1854 in the ERSST timeseries (panel b), not cooling. In addition, a cooling trend in the Sr/Ca-SST reconstruction is difficult to assess given the very large amplitudes from 1850-1900 (which are substantially larger than the ERSST product). If I'm looking at the wrong figure or panels, one solution is to specifically reference the figures you are referring to here, but I'm not sure how Figure S4 supports this conclusion.

Line 225: What's the correlation and significance between SODA salinity and the d18Osw record?

Lines 264-267: It would help if the authors explained the main point here a little more clearly, perhaps explaining that a positive correlation is opposite to what would be expected given that more rainfall should relate to more depleted d18Osw.

Line 271: It would help to explain right away what negative/positive anomalies represent. The authors do provide this explanation in lines 274-275, but moving this up would be helpful.

Lines 281-282: It would help to explain what a positive correlation means in terms of how changes in zonal wind stress impact d18Osw. This would help emphasize your conclusion that the coral is recording an advected ocean signal.

Lines 285-287: It would help if you highlighted the region you are referring to on the map in Figure 7.

Lines 313-315: I don't agree that Figure S8 demonstrates that the d18Osw records "largely co-vary with regional rainfall." While there are small pockets of correlation, this doesn't appear to be a broad-scale regional signal.

Figure 2: the dark red line is very difficult to see apart from the red shading. The authors may also want to note the inverted axis in panel c in the figure caption.

Figure 4: This caption is very difficult to understand. I suggest explaining the figures by panel.

Figure 5: Please use color. The gray and black timeseries are difficult to differentiate.

Figure 7: Please use the same y axis for all panels and explain what the green lines represent in the figure caption. It would also be useful to somehow highlight the lags/periods of interest that are discussed in the text.

Figure S1: add a,b,c,d to panels

Figure S2: It seems that the Ifaty d18Osw annual record is greatly underestimating the seasonal extremes when compared to the high res d18Osw record, for example in the 1990s. It seems that a higher-resolution comparison may be needed to confirm these results.

Figure S3: Please use color in panel b.

Figure S8: I can't read any of the small text at the top of each panel. Please make this larger or include in the figure in another way. Also, please include labels/names for each coral site within each panel.

