Comments on « Glacial-interglacial changes and Holocene variations in Arabian Sea denitrification » by Gaye et al.

In this study, the authors analyze the changes in SST and $\delta^{15}N$ in two new sediment cores of the Arabian Sea concomitantly with several other cores, during the last glacial interglacial and Holocene periods. They show how the $\delta^{15}N$ and SST records reflect the changes in OMZ and monsoon intensities and their interplay.
The study is well conducted, the questions that can arise during the reading are answered in the discussion part and several hypotheses on the changes of $\delta^{15}N$ values are discussed. The part analyzing the model simulation lack details and information.

Specific comments:

My field of expertise does not extend to the temperature and $\delta^{15}N$ reconstructions, so I won't comment much on that part.

Page 11 l239-247, the authors discuss the possible bias due to the differences between the Mg/Ca and alkenone proxies used to reconstruct SST. The authors state that the results from both methods "may thus be comparable" but only one verification has been made.
They argue that a strong correlation has been found between the two methods of reconstruction in one core of the Gulf of Aden. Is it the case for the other cores? How can one good correlation found in one core can justify that both methods are comparable for all the cores used in this study ?

Page 15 l332-335, the authors assume that the lower temperature off Oman compared to the Somali upwelling region during the last Glacial was due to enhanced NE monsoon circulation. Is it possible that a change in the summer wind orientation could also contribute to this pattern in the SST field? If the Findlater jet has a more zonal orientation then it could still sustain the Oman upwelling activity while reducing the Somali upwelling intensity. Some papers such as Sirocko et al. (1991), Anderson and Prell (1992), Bassinot et al. (2011), Le Mézo et al. (2017) have shown that the low-level jet could have moved in the past with potential effects on upwelling and productivity.
Later on page 16 l360-362, can the delay between the moisture decrease and the upwelling index decrease during the Holocene be also somehow explained by a shift in the summer monsoon winds? Can a shift in the wind orientation be able to allow for a sustained upwelling but less moisture transport on land ?

The authors wrote that during the Glacial, the enhanced NEM is supposed to increase convective mixing, which in turn can cause erosion of the OMZ. During the Holocene, the NEM increases from the early to the late Holocene and the result is that productivity increases, which reduces oxygen and intensify the OMZ to the north. Is the difference of increased NEM effects due to the change in circulation in the Arabian Sea between the Glacial and the Late Holocene ?

The authors use a model results at the end of the paper to discuss the residence time of OMZ waters. The reference "Aumont et al. 2003" describes the PISCES model while the reference "Park and Latif 2008" describes the variability of the meridional overturning circulation within the KCM model. I have the feeling that this second reference is not precise enough for the topic of this paper. Is there any paper analyzing the model's ability to reproduce the OMZ in the Arabian Sea ? If not, then a model evaluation is needed here. We need to know if the model is able to reproduce realistic water masses distribution, OMZ extent and productivity/export production distribution in the Arabian Sea to be convinced that the changes it produces throughout the Holocene are not some kind of artefact.
Moreover, how this transient simulation has been realized ? Is there a reference for that?
You can also cite Park et al. 2009, which gives more details about the KCM model than Park and Latif 2008.

References :

Sirocko, F., Sarnthein, M., Lange, H., and Erlenkeuser, H.: Atmo- spheric summer circulation and coastal upwelling in the Ara- bian Sea during the Holocene and the last glaciation, Quaternary Res., 36, 72–93, https://doi.org/10.1016/0033-5894(91)90018-Z, 1991.

Anderson, D. M. and Prell, W. L.: The structure of the southwest monsoon winds over the Arabian Sea during the late Quater- nary: Observations, simulations, and marine geologic evidence, J. Geophys. Res., 97, 15481, https://doi.org/10.1029/92JC01428, 1992.

Bassinot, F. C., Marzin, C., Braconnot, P., Marti, O., Mathien-Blard, E., Lombard, F., and Bopp, L.: Holocene evolution of summer winds and marine productivity in the tropical Indian Ocean in re- sponse to insolation forcing: data-model comparison, Clim. Past, 7, 815–829, https://doi.org/10.5194/cp-7-815-2011, 2011

Le Mézo, P., Beaufort, L., Bopp, L., Braconnot, P. and Kageyama, M.: From monsoon to marine productivity in the Arabian Sea: insights from glacial and interglacial climates, Clim. Past, 13, 759-778, https://doi.org/10.5194/cp-13-759-2017, 2017

Park, W., N. Keenlyside, M. Latif, A. Ströh, R. Redler, E. Roeckner, and G. Madec, 2009: Tropical Pacific Climate and Its Response to Global Warming in the Kiel Climate Model. *J. Climate,* **22**, 71–92, https://doi.org/10.1175/2008JCLI2261.1

Minor comments

Throughout the text there is a mismatch between the Figure 1 labels a and b and the reference to this figure panels: a is referenced as b and inversely (page 5 l 93, l97, page 11 l234, l249)

The name of the new cores varies throughout the text. Be consistent and choose between SL163, 163SL, SL 163, 163 SL also MC680, MC 680

Page 3 l57: you can maybe give a reminder of the definition of $\delta^{15}N$ (shorter than what you do later).

Page 5 l108 : I don't think it is necessary to add the acronym "DNRA" in brackets since you do not use it afterwards.

Page 10 l209: The reference “Sonzogni et al. (1997)” is the reference a or b ?

Page11 l250: “δ^{15}N values were normalized to an average value”, what is this average value ?

Page12 l276: “the SST minimum was situated in the northern Arabian Sea”, it seems by looking at Figure3 that the minimum is in the Oman upwelling. Do you include the Oman upwelling when you state “the northern Arabian Sea” here?

Page13 l284: “Holocene δ^{15}N values.. (Fig. 5a)” are you describing the values on figure 5a, if so you should use “Present δ^{15}N values” as stated on the figure for clarity. If you are also describing figure 6, then you should state it as “(Figs. 5a and 6)”.

Page14 l328: “(Fig. 3b)” I believe you mean Fig. 2b ?

Page 15 l345-350: Do we see a Younger Dryas effect in the moisture index? If not, why ?

Page 15 l354: What do you call “climatic deterioration” ?

Page 16 l361-362: Precise “summer sea surface temperatures ... winter SST”

Page 16 l372: “This is identical to the signal of sub-thermocline nitrate, ”

Page 17 l386: “time interval”

Page 19 l445-460: Is the TOC MAR record a mean over the whole Arabian Sea ? You should precise where does it come from.

Page 20 l467: At which depth is calculated the export production?
“(Fig. 8)”

Comments on the Figures and table

Table 1:

- Line of core MD85668 (before the horizontal bold line) : Latitude is -0.01667S you should write 0.01667N to be consistent with the other cores.
- Line of core NIOP455 (Second line under the bold horizontal line) : δ^{15}N is written d15N in the last column.

Figure 1:

- You should invert panel a and b to be consistent with the text (or change it throughout the text).
- You could also add the captions δ^{15}N and SST on the panels.

Figure 2:

- add the units next to the color scale

- missing reference to World Ocean Atlas in the figure caption

Figure 3 :

- You should keep the same colors as in Figure 1. For the southeast area choose between orange and pink and modify either Figure 1 or Figure 3.
- In the legend, the symbols have a black contour but not the lines in the plot (except for the northern area). You should also be consistent there.

Figure 4:

- Units for the colorbars
- You should invert the panels order since in the text you first discuss panel b and then panel a
- Figure caption : put "(1955-2012)" after "World Ocean Atlas" as in the caption of figure 2. You could add also the reference for this data.

Figure 5:

- Units

Figure 6:

- Missing units for the insolation curve
- Figure caption: you could add the units of the plotted variables as in the other figures' caption

Figure 7:

- Figure caption:
  p33 l904-906 "Millenial regional averaged SST… averaged SST .. averaged SST" or write "Millenial regional SST average … SST average … SST average" or as in the caption of figure 3 "average of SST".

References in the paper:

There are cited papers not referenced in the bibliography section, and papers in the bibliography not present in the text.

IN the text **NOT** in the biblio :

Reference	Page and line
Altabet et al., 1999	p7 l159-160
Aumont et al., 2003	p20 l461-462
Annan and Hargreaves, 2013	p14 l319-320, p14 l321 (is it a typo for Annan and Hargreaves **2003** ?)
Bulow et al., 2010	p5 l108
Devol 1978	p7 l147
Haake et al., 1993	p6 l115
Nair et al., 1989	p6 l115
Naqvi et al., 2008	p4 l64
Olson et al., 1993	p6 l111, p6 l122
Reichart et al., 1997	p7 l160
Rixen et al., 1996	p6 l115

Schulte et al., 1999	p7 l160
Shankar and Shetye, 2001	p14 l308-309
Ward et al., 2008	p5 l109
You 1998	p6 l129

IN the biblio **NOT** in the text
Annan and Hargreaves, 2003
Budziak 2004
Schlitzer 2016