Clim. Past Discuss.,
https://doi.org/10.5194/cp-2020-23-RC2, 2020

Climate of the Past
Discussions

Interactive comment on "Sea surface temperature in the Indian sector of the Southern Ocean over the Late Glacial and Holocene" *by* Lisa C. Orme et al.

Anonymous Referee #2

Received and published: 15 April 2020

Title: Sea surface temperature in the Indian sector of the Southern Ocean over the Late Glacial and Holocene Authors: Lisa C. Orme et al. MS No.: cp-2020-23 MS Type: Research article

Overview and general recommendation

The sequence of warmings and coolings associated with the last deglaciation and the Holocene has shown contrasting patterns between southern and northern high latitudes. Global-scale processes such as variations of AMOC strength and the alteration of atmospheric circulation seem responsible for this contrast. Most of the high-resolution paleorecords studied so far were gained from Antarctic ice cores. Therefore, acquiring high-resolution proxy records of past sea surface temperature is relevant for finding out how spatio-temporal patterns of water temperature evolved in the Southern Ocean and whether any links with Antarctic temperature variability are recognized.

Orme and co-authors present a high-resolution, diatom-based record of sea-surface temperature gained in the western Indian sector of the Southern Ocean (Core KH-10-7 COR1GC, ca. 54.27°S, 39.77°E, WD 2834 m). Their sediment record spans the past 14.2 Ka BP. The age model bases on fifteen AMS radiocarbon dates obtained on mono-specific samples of the planktic foraminifera Neogloboquadrina pachyderma sin. The average temporal resolution of their diatom counts is ca. 60 years (diatom analysis was conducted every cm in the 2.48 m gravity core). By using the Modern Analogue Technique applied to diatom assemblages, Orme and colleagues estimate the summer SST and the winter sea ice concentration. They describe and discuss patterns, timing and magnitude of sea-surface temperature variability through the late deglaciation and the Holocene in the western Indian sector of the Southern Ocean and possible links to global and regional forcings and mechanisms.

The Introduction presents basic information on (1) deglacial events and Holocene intervals, and (2) main mechanisms/forcings behind temperature in the Southern Ocean; it reads well and helps the reader less familiar with issues addressed later in the MS. The Methodology is clearly written. Results are concisely presented; the results representation however can improve (see suggestions below). Figures are self-explanatory and necessary in number. References are satisfactory.

A major concern is how the Discussion is organized. Throughout the Discussion, there are several inconsistencies and several vague statements that lack scientific support. Some ideas are shortly presented, without any further and deeper discussion. Too many forcings and mechanisms are offered as possible explanations for the SST variations (solar forcing, internal climate variability, sea-ice and productivity changes, ocean-atmosphere coupling, rapid climate change events globally, establishment of modem ENSO amplitude and frequency), without clearly distinguishing which mechanism/forcing/s was/were more important when, and the reader gets lost. Please consider: (1) shortening and focusing the discussion, and (2) adding a Table summarizing with main mechanism/forcing/s for each for each of the discussed intervals.

Below I list several minor comments and give some suggestions which might be helpful to improve your MS: L. 66-67: this is repeated several times throughout the Intro. Please revise. L. 93-94: since the authors state that 'Topography has a strong influence on the position and form od the ACC in this region', they should provide a more detailed figure of the study area in Fig. 1, including bathymetric information. L: 108: Neogloboquadrina pachyderma should be in italics. L. 115-125: Using reservoir age from a core gained in a mid-latitude coastal upwelling system is -at the least-risky and caution is advised. Oceanographical and nutrient conditions in the SE Pacific Ocean are quite different from those in the Conrad Rise and can hardly be straightforwardly applied. The high-resolution sampling (every cm) make the age model uncertainties even larger. Additionally, reworking should be considered/discussed. L. 145-46: these three processes strongly impact your diatom signal (the basis of your SST reconstructions), but it is hardly discussed in 5. Discussion. L. 172: please give age ranges for the Holocene (which age definition of Holocene did you follow?) I suggest adding a box in the upper part of Fig 4, indicating the main intervals of the last deglaciation (YD, ACR, etc.) and Holocene (early/middle/late). This is presented later in Fig 7, but it should be earlier when Results are described. L. 173-183: References for the paleoecological information of the diatom species should be provided here. The reader does not know where the species ecology does come from. L. 184: 'The estimated total diatom abundance shows a decreasing trend through the record', please revise this statement. It is not quite correct to state that the total diatom abundance (TDA) shows an overall decreasing between last deglaciation and the latest Holocene. Indeed, TDA varies strongly up to 5.5 Ka BP and experienced afterward a two-step decrease, first around 5.5 Ka BP and later between 4 and 1 ka BP. L. 190-198: all short intervals mentioned here should be easily recognizable in Fig 4. Please add some arrows to help the reader to better understand what you are trying to communicate. More-over, add marks between millennial ages in Fig 4: your Results description goes into centennial-scale description (e.g., Between 11.6 and 8.7 ka BBT, etc). Without these centennial-scale marks is even more difficult to recognize whichever trends and shifts occurred. L. 210: 'high temperatures between 11.6 and 8.7 ka BP during the Early Holocene, followed by a cooling trend thereafter': this is a matter of interpretation. The range of SST variability is larger (larger amplitude) between 8 and 1 ka BP than earlier between 8.2 and 11.8 ka BP. However, is it correct to state that a cooling occurred during the middle to late Holocene? I am not able to recognize a clear decreasing trend in your data depicted in Fig. 7d. L. 215: 'Although most records, including COR1GC, show a long-term cooling over the Holocene (Xiao et al., 2016)'. Please revise: the PS2606-6 SST record shows similar values during YD and the entire Holocene. SO, where is the Holocene cooling? L. 218: 'The records from Bouvet Islands', where is this? Which sector of the SO? Please provide more accurate information. L. 222-23: 'Our new record from core COR1GC conversely shows SSTs were 1°C lower during the ACR compared to the mid-late Holocene', Is this 1°C difference statistically significant? 1°C of SST difference lays surely within the range of variability of your SST reconstruction. L. 233: can a 2-3°C rise of SST during the Holocene -compared to last deglaciation- as WARM conditions? I understand that it was warmer, but it is not a warm environment per se, mainly when your SST reconstructions is compared with records from mid and low latitudes. L. 241-43: I agree with these mechanisms and forcings impacting the reconstructed SST record at your core site. However, since diatoms experience dissolution between sea surface and the bottom of the ocean, I can assume that your reconstructed SST values vary depending on which species did it to the sediment. There is, however, no discussion on the possible role of preferential dissolution/preservation of diatoms (see also l. 145-46). L. 245: 'Southern high latitude warming (Termination 1b) during the Younger Dryas', this is given as one unique interval before (see l. 209-10). Please revise and rephrase correspondingly. L. 266-67: 'Greater upwelling has been shown by higher opal deposition to the south of the Polar Front in the Southern Ocean (Atlantic, Indian and Pacific sectors) through the period

Printer-friendly version

Discussion paper

12.7- 11.5 ka BP‘, this is true. However, your TDA data do not show any significant difference among ACR, YD, and early Holocene. Therefore, your data offer no convincing evidence of an intensification of upwelling following the last deglaciation. L. 275-76: ‘as tentatively inferred from the slightly increased diatom abundances at 12.7-12 ka BP’. This is hardly recognizable in your COR1GC record. Your TDA does not actually differ from earlier and later values. Please revise. L. 283-84: ‘Indeed a southward shift is indicated by an increase in Polar Front species at c. 12 ka BP‘, you mean Thalassionema nitzschioides var. nitzschioides? The increase is not that clear in F. kerguelensis. L. 296: ‘has been attributed to high annual, winter and spring insolation levels‘, please clarify: do you mean average annual insolation or winter and spring insolation? L. 315: SSW’s, misspelling. See also below l. 317. L. 316: ‘together can explain the gradual cooling in the COR1GC record‘, please provide SST range, average and 1STD for your mid and late Holocene SST record. L. 320: ‘however it is not clear if this occurred as although there was a gradual increase in sedimentation rate, potentially reflecting an increased deposition of diatoms‘. Be cautious with this: according to your data, no increase in total diatom abundance occurred at this time. L. 326-340: this is a quite different story from all the above discussion and confuses the reader. Several forcings are mentioned/shortly discussed in 14 lines (solar forcing, internal climate variability, sea-ice and productivity changes, ocean-atmosphere coupling, rapid climate change events globally, establishment of modem ENSO amplitude and frequency). Presenting an alternative climate scenario at the very end of the manuscript (rapid climate change events globally and establishment of modem ENSO amplitude and frequency), without any further discussion makes this subsection even more confusing and does not add anything valuable to your overall Discussion.

Figures Fig 1: please consider (1) zooming into the closest area to core COR1GC (include bathymetry), and (2) identifying the Atlantic, Indian and Pacific sectors of the Southern Ocean. In the caption the references for cores TN057-13-PC4, TN057-17-PC1, MD07-3088, EDML, and EDC should be presented. Fig. 3: note that you name core COR1GC differently depending on the figures. Please revise. var. in Thalassionema nitzschioides var. nitzschioides should not be italics. Thalassiosira oestrupii has been renamed for years already, the current name is Shionodiscus oestrupii. Consider using exponential nomenclature for x-axis of TDA. Consider adding some arrows to lead the reader in better understanding major shifts/changes in (1) the species composition of the diatom assemblage, and (2) total diatom abundance. Fig. 4: Please consider adding a box in the upper panel indicating YD, early/mid/late Holocene, etc. (see Fig 7) Consider also adding the (1) average and 1STD of your own data, and (2) present-day summer and winter SSTs., and (3) present-day mean winter sea ice concentration. Fig. 7: the long-term pattern of your SST data is pretty similar to that of East Antarctica cores: low ACR values, increase during the YD, and warmer Holocene SST. A simple statistical analysis should help you to better understand the trends. Your SST record shows ten SST minima (cooling) during the Holocene: it seems to me that most of these minima are made by only ONE sample. This can be part of regular variability of the diatom assemblage and not at all related with actual SST variations. Caution is advised in the interpretation of these minima!

Interactive comment on Clim. Past Discuss., https://doi.org/10.5194/cp-2020-23, 2020.