Clim. Past Discuss., 9, C2663–C2667, 2013
www.clim-past-discuss.net/9/C2663/2013/

Climate of the Past Discussions
Open Access

Interactive comment on "Migrating subtropical front and Agulhas Return Current affect the southwestern Indian Ocean during the late Quaternary" *by* D. K. Naik et al.

M. Simon

simonmh@cardiff.ac.uk

Received and published: 9 December 2013

The manuscript "Migrating subtropical front and Agulhas Return Current affect the southwestern Indian Ocean during the late Quaternary" by Naik et al. uses stable isotope and trace element data in combination with abundance counts of planktonic foramiferal species Globigerinoides bulloides and Neogloboquadrina pachyderma dextral to interfere changes in the hydrography of the SW Indian Ocean during the past glacial-interglacial cycle. The author argues that shifts of the position of the "retroflection region" as well as the migration of the Subtropical Front (STF) are responsible for the observed changes in the record. The study is interesting and offers important

new data from the Agulhas Return Current, which is an area currently poorly represented in terms of paleoceangraphic records. Nevertheless, some terminology used in the manuscript is partly incorrect and interpretations drawn are outdated and/or one-sided. The author should consider and include some recently published articles in their interpretation, which will help to better constrain the observed features in their records. The manuscript in its present form creates a misleading picture of the dynamics of the Agulhas Current system during past climates. Below I summarised my main remarks.

Detailed comments:

Line 10 p 5522 and throughout the manuscript: Agulhas Retroflection Region (ARR). This term used to describe the core location and local hydrography is used incorrectly. The Agulhas Retroflection is situated approximately at 21°E (Gordon et al., 1987). The core studied here SK 200/17 (39.03 °S ; 44.97°E) is situated in the area between 40 and 50°E where approximately 20Sv of Agulhas Return Current waters recirculate northward into a southwest Indian Ocean subgyre (SWIOSG) partly supplying source waters for the Agulhas Current itself; (Stramma and Lutjeharms, 1997). A better term would be the Agulhas Recirculation Region.

Line 22 p 5523: "The latitudinal migration of STF affects transport of water from the southwestern Indian Ocean to the Atlantic Ocean by the Agulhas Current (Flores et al., 1999)". This statement and the reference is outdated and the author should consider and include in his interpretations recent publications showing new results on the link between the migration of the STF and Agulhas leakage intensity (De Boer et al., 2013; Durgadoo et al., 2013; Graham and De Boer, 2013; Graham et al., 2012). Line 17 p 5532: "It is possible that G. bulloides Mg/Ca at the core site is affected by partial dissolution as the core site lies below the modern carbonate saturation horizon". As the other reviewers have already pointed out the influence of carbonate dissolution on the used foraminifera should be better constrained. A recent study on core material from 3333m water depth in the SW Indian Ocean (29°E, 33°S) showed significant influence of dissolution (Simon et al., 2013). This work provides a detailed assessment

CPD
9, C2663–C2667, 2013

of carbonate dissolution as well as an approach how to adjust for it and can potentially provide some guidance for this study.

Line 5 p 5533: "As compared to early Holocene, a high relative abundance of G. bulloides throughout the last glacial period especially during MIS 4 and 2, suggests high productivity in the southwestern Indian Ocean during cold periods". While I agree with the author's interpretation that high abundances G. bulloides can be related to high productivity as the Agulhas Return Current is found to exhibit high concentrations of chlorophyll-a (Lutjeharms, 2006). Nevertheless, the author should consider other mechanism which could explain high abundances of G. bulloides and N. pachyderma dextral in the area linked to the stronger northward advection of polar to transitional waters originating from south of the dynamical STF and their influence on the Agulhas Return Current during glacials (Simon et al., 2013)

Line 10-21 p 5535: Care should be taken with generalised statements such as: "when the STF moved to such a northerly position that it helped to force early retroflection of Agulhas Current, thus bringing warm and salty water to the core location".

1) Franzese et al. (2009) showed that the glacial Agulhas Current followed closely its modern trajectory and that the position of the Agulhas retroflection stayed the same. 2) The Agulhas Current SSTs itself were reduced up to 4° C during MIS 4 and MIS 2 making it less likely that the current brought warm waters to the core location in this study (Simon et al., 2013). 3) The position of the STF during glacial is still under debate and the picture arising from a variety of studies displays a equivocal picture from no shift at all to about a range of 3-5 degrees. (Kohfeld et al., 2013). Bard and Rickaby (2009) estimate of a 7 degree northward shift in the position of the STF was related to the most severe glacial stages MIS 10 and MIS 12. Based on idealized model output this seem a less likely scenario according to recent results e.g. Kohlfeld et al. (2013).

p 5536-5538 section: 6.4 Subtle temperature salinity change: role of Agulhas retroflection current. The entire discussion here (as well as partly earlier throughout the

CPD

9, C2663–C2667, 2013

manuscript) needs rethinking. The assumption that increased transport of subtropical warm water by ARC will warm the "Agulhas Retroflection Region" during glacials due to an easterly shifted retroflection is not supported by the data shown in the manuscript or by the published literature. Missing glacial-interglacial temperature gradients in the Mg/Ca derived estimates here might be a result of dissolution lowering the original Mg/Ca ratios. Increases in N. pachyderma dextral could be a result of Southern component water advection into the area rather than a response to subsurface warming. Moreover there is little evidence that the Agulhas Return Current was transporting warmer waters during glacials as shown by Simon et al. (2013) as well as by a recently published record from the Agulhas Plateau. Temperatures also based on G. bulloides Mg/Ca ratios within the Agulhas Return Current shows glacial cooling of up to 3°C (Marino et al., 2013).

References

De Boer, A.M., Graham, R.M., Thomas, M.D., Kohfeld, K.E., 2013. The control of the Southern Hemisphere Westerlies on the position of the Subtropical Front. Journal of Geophysical Research: Oceans 118, 1-7.

Durgadoo, J.V., Loveday, B.R., Reason, C.J.C., Penven, P., Biastoch, A., 2013. Agulhas Leakage Predominantly Responds to the Southern Hemisphere Westerlies. Journal of Physical Oceanography.

Franzese, A.M., Hemming, S.R., Goldstein, S.L., 2009. Use of strontium isotopes in detrital sediments to constrain the glacial position of the Agulhas Retroflection. Paleoceanography 24, PA2217.

Gordon, A.L., Lutjeharms, J.R.E., Gründlingh, M.L., 1987. Stratification and circulation at the Agulhas Retroflection. Deep Sea Research Part A. Oceanographic Research Papers 34, 565-599.

Graham, R.M., De Boer, A.M., 2013. The Dynamical Subtropical Front. Journal of

CPD

9, C2663–C2667, 2013

Geophysical Research: Oceans 118, 1-7.

Graham, R.M., de Boer, A.M., Heywood, K.J., Chapman, M.R., Stevens, D.P., 2012. Southern Ocean fronts: Controlled by wind or topography? Journal of Geophysical Research: Oceans 117, C08018.

Kohfeld, K.E., Graham, R.M., Boer, A.M.d., Sime, L.C., Wolff, E.W., Quéré, C.L., Bopp, L., 2013. Southern Hemisphere Westerly Wind Changes during the Last Glacial Maximum: Paleo-data Synthesis. Quaternary Science Reviews 68, 76-95. Lutjeharms, J.R.E., 2006. Three decades of research on the greater Agulhas Current. Ocean Sci. Discuss. 3, 939-995.

Marino, G., Zahn, R., Ziegler, M., Purcell, C., Knorr, G., Hall, I.R., Ziveri, P., Elderfield, H., 2013. Agulhas salt-leakage oscillations during abrupt climate changes of the Late Pleistocene. Paleoceanography VOL. 28, 599-606.

Simon, M.H., Arthur, K.L., Hall, I.R., Peeters, F.J.C., Loveday, B.R., Barker, S., Ziegler, M., Zahn, R., 2013. Millennial-scale Agulhas Current variability and its implications for salt-leakage through the Indian–Atlantic Ocean Gateway. Earth and Planetary Science Letters 383, 101-112.

Stramma, L., Lutjeharms, J.R.E., 1997. The flow field of the subtropical gyre of the South Indian Ocean. J. Geophys. Res. 102, 5513-5530.

Interactive comment on Clim. Past Discuss., 9, 5521, 2013.