PP53D-1472

Tracking Spread of the Agulhas Leakage Into the Western South Atlantic and Its Northward Transmission During the Last Interglacial

Ballalai, João M. [1]; Santos, Thiago P. [1]; Lessa, Douglas O. [1]; Venancio, Igor M. [2]; Chiessi, Cristiano M. [3]; Johnstone, Heather J. H. [4]; Kuhnert, Henning [4]; Claudio, Marcela R. [1]; Toledo, Felipe[5]; Costa, Karen B. [5]; Albuquerque, Ana Luiza S.[1]

[1]Programa de Geociências (Geoquímica), Universidade Federal Fluminense, Niterói, Brazil, [2]Center for Weather Forecasting and Climate Studies (CPTEC), National Institute for Space Research (INPE), Cachoeira Paulista, Brazil, [3]Escola de Artes, Ciências e Humanidades, Universidade de São Paulo, São Paulo, Brazil, [4]MARUM-Center for Marine Environmental Sciences, University of Bremen, Bremen, Germany, [5]Laboratório de Paleoceanografia do Atlântico Sul, Instituto Oceanográfico, Universidade de São Paulo, Brazil

Introduction

Intensification of the Agulhas Leakage (AL) during glacial terminations has long been proposed as a necessary mechanism for reverting the Atlantic Meridional Overturning Circulation (AMOC) to its interglacial mode. This exchange is a central component of the meridional circulation maintaining the salinity, strength, and stability of deep-water convection. Once in the South Atlantic, convection and air-sea interactions modify AL signal, with advection westwards strengthening its positive salt anomaly resulting in the South Atlantic thermocline being saltier in areas influenced by the AL. However, lack of records showing the downstream evolution of AL signal and substantial temporal differences between AL intensification and resumption of deep-water convection have cast doubt on the importance of this mechanism to the AMOC. Here, we analyze a combination of new and previously published data relating to Mg/Ca-derived temperatures and ice volume-corrected seawater $\delta^{18}O$ records ($\delta^{18}O_{IVC\text{-}SW}$, as a proxy for relative changes in ocean salinity), which demonstrate propagation of AL signal via surface and thermocline waters to the western South Atlantic (Santos Basin) during Termination II and the early Last Interglacial.

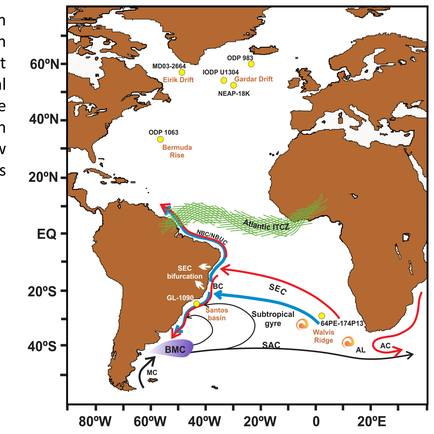


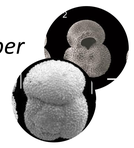
Fig. 1: Schematic representation of mean circulation of the South Atlantic subtropical gyre (based on Stramma & England, 1999), the Agulhas Current (AC), and the mean position of the Intertropical Convergence Zone (ITCZ). The most relevant surface and thermocline currents for this study are shown by thick red and blue lines, respectively. The yellow dots show the positions of core GL-1090 (this study) and other cores discussed herein.

Methods and Materials

We investigated the core GL-1090 (24.92 °S, 42.51 °W, 2225 m water depth, 1914 cm long) located in the western South Atlantic, at Santos Basin, Brazil. Here, we analyze a combination of new and previously published data relating to Mg/Ca-derived temperatures and ice volume-corrected seawater $\delta^{18}O$ records ($\delta^{18}O_{IVC\text{-}SW}$, as a proxy for relative changes in ocean salinity), which demonstrate propagation of AL signal via surface and thermocline waters to the western South Atlantic during Termination II and the early Last Interglacial.

Globigerinoides ruber

Globorotalia inflata



References:

- Marcello, F., Wainer, I., & Rodrigues, R. R. (2018). South Atlantic Subtropical Gyre Late Twentieth Century Changes. Journal of Geophysical Research: Oceans, 123(8), 5194–5209. https://doi.org/10.1029/2018JC013815
- Rodrigues, R. R., Rothstein, L. M., & Wimbush, M. (2007). Seasonal Variability of the South Equatorial Current Bifurcation in the Atlantic Ocean: A Numerical Study. Journal of Physical Oceanography, 37(1), 16–30. https://doi.org/10.1175/JPO2983.1
- Santos, T. P., Lessa, D. O., Venancio, I. M., Chiessi, C. M., Mulitza, S., Kuhnert, H., … Albuquerque, A. L. S. (2017). Prolonged warming of the Brazil Current precedes deglaciations. Earth and Planetary Science Letters, 463(April), 1–12. https://doi.org/10.1016/j.epsl.2017.01.014
- Stramma, L., & England, M. (1999). On the water masses and mean circulation of the South Atlantic Ocean. Journal of Geophysical Research: Oceans, 104(C9), 20863–20883. https://doi.org/10.1029/1999JC900139

Results and Discussion

The saline AL waters were temporally stored in the upper subtropical South Atlantic until they were abruptly released in two stages into the North Atlantic via surface and thermocline waters at ca. 129 and 123 ka BP, respectively. Accounting for age model uncertainties, these two stages are coeval with the resumption of convection in the Labrador and Nordic seas during the Last Interglacial. We propose a mechanism whereby both active AL and a favorable ocean-atmosphere configuration in the tropical Atlantic were required to allow flux of AL waters into the North Atlantic, where they then contributed to enhancing the AMOC during the Last Interglacial period. Our results provide a framework that connects AL strengthening to the AMOC intensifications that followed glaciations.

Salinification of the Upper Subtropical South Atlantic Associated With Strengthening of the Agulhas Leakage

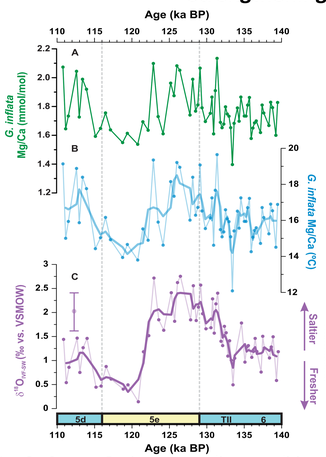


Fig. 2: Santos Basin thermocline conditions, as assessed from *Globorotalia inflata* shells in core GL-1090.

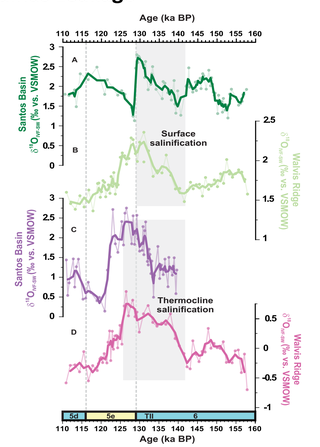


Fig. 3: Evolution of the surfaces and thermoclines of eastern (Walvis Ridge) and western (Santos Basin) South Atlantic ice-volume-corrected seawater $\delta^{18}O(\delta^{18}O_{IVC\text{-}SW})$ values during the Marine Isotope Stage (MIS) 6/5e transition.

Abrupt Bi-Phase Freshening of the Western South Atlantic and the AMOC During the Last Interglacial

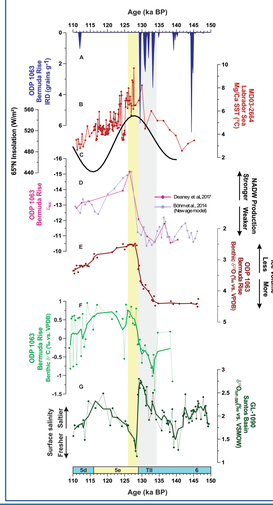


Fig. 4: Conditions associated with resumption of deep-water convection in the Labrador Sea during early-Marine Isotope Stage (MIS) 5e.

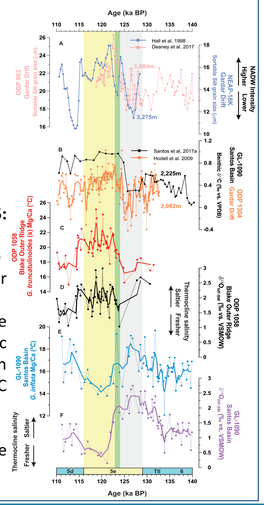


Fig. 5: Thermocline ice-volume-corrected seawater $\delta^{18}O(\delta^{18}O_{IVC\text{-}SW})$ values from the South Atlantic and resumption of the AMOC during mid-Marine Isotope Stage (MIS) 5e.

Results and Discussion

The Role of Tropical Ocean-Atmosphere Coupling in Atlantic Inter-Hemispheric Salt and Heat Exchange

The position of the SEC bifurcation is associated with seasonal movements of the Intertropical Convergence Zone (ITCZ) (Rodrigues et al., 2007) and determines whether waters of the upper South Atlantic become part of the return flow of meridional overturning, or if they recirculate within the South Atlantic subtropical gyre by favoring either the North Brazilian Current or the Brazilian Current, respectively (Marcello et al., 2018). We suggest that a southerly position of the ITCZ at the end of the penultimate glacial period, which shifted the SEC bifurcation to a more northerly position, functioned as a "barrier" that enhanced flow of the BC and limited cross-equatorial transmission of the salty AL waters that recirculated within the South Atlantic subtropical gyre.

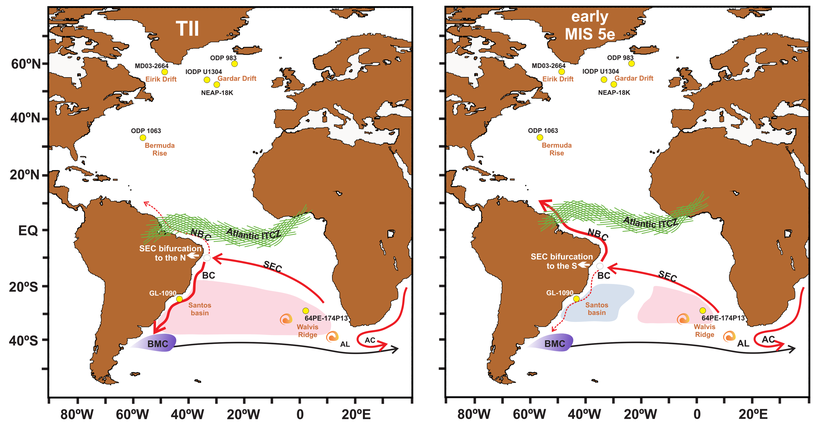


Fig. 6: Schematic of positions of the ITCZ, surface circulation of the South Atlantic, and relative evolution of sea surface salinity during Termination II (left panel) and the early-Last Interglacial (right panel). The yellow dots show the positions of core GL-1090 (this study) and other cores discussed herein

Conclusions

- Establishment of the Last Interglacial climate, which included a vigorous AMOC, occurred via two steps, with resumption of convection in the Labrador and Nordic seas during the early- and mid-MIS 5e
- Salty waters flushed into the Atlantic Ocean from the Indian Ocean during TII and early-MIS 5e can be detected in the western South Atlantic, where they were stored from the end of the penultimate glacial
- Transmission of these dense saline waters into the North Atlantic probably accounted for dynamics of the AMOC during the Last Interglacial
- Our study presents a framework in which strengthening of the AL can be linked to stabilization of the overturning that followed the penultimate glaciation

Acknowledgments: We thank R. Kowsman (CENPES/ Petrobras) and Petrobras Core Repository staff (Macaé/Petrobras) for providing sediment core GL-1090. T.P.S acknowledges the financial support from CAPES/IODP (grant 88882.151088/2017-01) and CAPES/PNPD (grant 88882.306119/ 2018-01). I.M.V. acknowledges the financial support from CAPES/PDSE (88887.1561152/2017-00 and 88881.161151/2017-01). A.L.A. is a CNPq senior researcher (grant 306385/2013-9) and appreciates their financial support (grant 99999.002675/ 2015-03). C.M.C. acknowledges the financial support from FAPESP (grant 2018/15123-4), CAPES (grants 564/2015 and 88881.313535/2019-01), CNPq (grants 302607/2016-1 and 422255/2016-5) and the Alexander von Humboldt Foundation. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - 23038.001417/2914-71. The data reported in this paper are archived in Pangaea (https://doi.pangaea.de/ 10.1594/PANGAEA.896152).