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Response of the Tropical Atlantic Ocean-Atmosphere System to Deglacial Changes in Atlantic Meridional Overturning

Stefan Mulitza,[1] Cristiano M. Chiessi,[2] Jörg Lippold,[3] Jean Lynch-Stieglitz,[4] Andreas Mackensen,[5] André Paul,[1] Matthias Prange,[1] Rodrigo Portilho Ramos,[1] Anna Paula S. Cruz,[6] Enno Schefuss,[1] Tilmann Schwenk,[1] Michael Schulz,[1] Ralf Tiedemann[5], Ines Voigt,[1] Martin Werner,[5] and Yancheng Zhang[1]

With 1 Figure

An important feature of the present-day circulation in the Atlantic is the cross-equatorial flow of warm and shallow waters from the South Atlantic into the North Atlantic. Much of this transport is maintained at the western boundary through the North Brazil Current, which is regarded as the major upper component of the modern Atlantic Meridional Overturning Circulation (AMOC) (Zhang et al. 2011). The associated heat transport into the North Atlantic promotes a northerly location of the Intertropical Convergence (ITCZ) (Marshall et al. 2014) and the associated rainfall maximum for much of the year. At the southern and northern limits of the ITCZ semi-arid conditions prevail in Northeast Brazil (Nordeste) and the Sahel.

Across the equator, the northward flow with the western boundary current is compensated through the southward flow of North Atlantic Deep Water (NADW) as the lower branch of the AMOC. This water mass is collectively formed from surface waters sinking in the Greenland, Iceland, Norwegian, and Labrador seas and is identifiable as a tongue of nutrient poor and ^{13}C rich water extending southward in the deep Atlantic (Kroopnick 1985). Nutrient-rich and low $\delta^{13}C$ Antarctic Bottom Water (AABW) formed in the Southern Ocean is penetrating northward below the NADW.

Since the AMOC underwent substantial variations during the last deglaciation (McManus et al. 2004), high-resolution sediment records from ocean margin settings offer the opportunity to study interactions between ocean circulation, continental climate and the carbon cycle. We present two previously unpublished sediment cores recently retrieved off NE Brazil (GeoB16202-2 and GeoB16206-1, ~2°S, 2248 m and 1367 m water depth) and one sediment core from the continental margin off NW Africa (GeoB9508-5, ~16°N, 2384 m water depth) (Fig. 1) covering the last deglaciation (Mulitza et al. 2008). Age models of all cores are based on calibrated AMS radiocarbon dates and show highly resolved deglacial sections with sedimentation rates up to 1 mm/year during Heinrich stadial 1 due to intensified terrigenous input. XRF elemental ratios of bulk sediments and δD of plant wax (Niedermeyer et al. 2009) have been used to characterize terrestrial climate. Protactinium/Thorium (Pa/Th) ratios

1 MARUM – Center for Marine Environmental Sciences, University of Bremen, Germany.
2 School of Arts, Sciences and Humanities, University of São Paulo, Brazil.
3 University of Bern, Institute of Geological Sciences, Switzerland.
4 School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, USA.
5 Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany.
6 Fluminense Federal University, Niterói, Rio de Janeiro, Brazil.

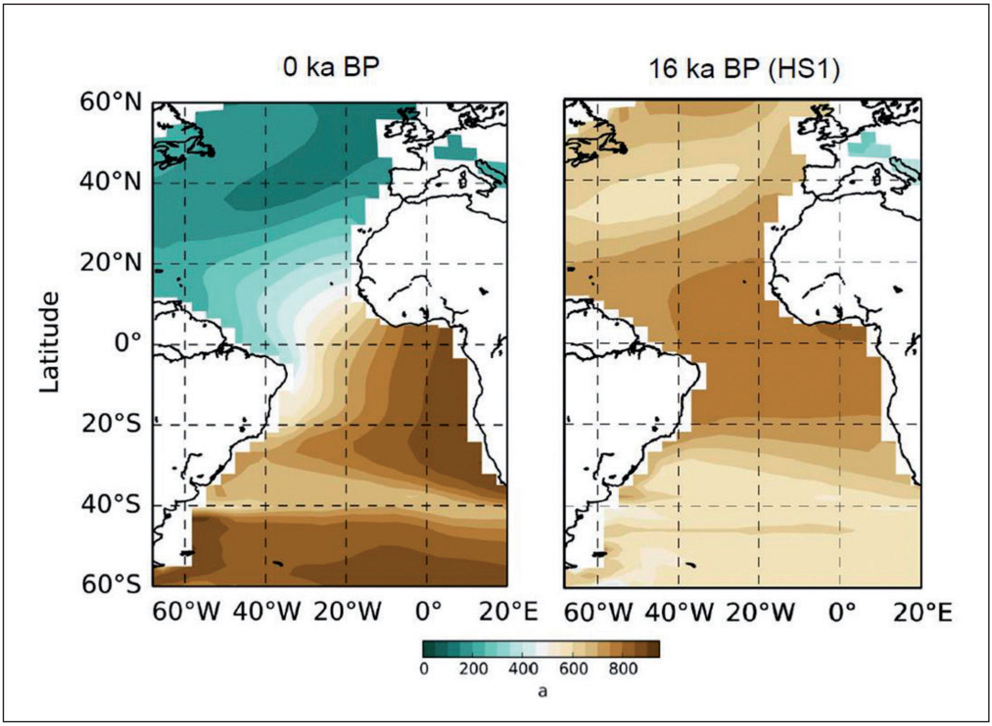

Fig. 1 Core locations and ideal age (1112.51 m depth) for the control run (0 ka BP) and Heinrich stadial 1 (16 ka BP) from climate model simulations of Liu et al. (2009). Ideal age (Thiele and Sarmiento 1990) is a tracer that is advected and mixed in the same way as temperature and salinity and records time since contact with the surface. The model data suggest the development of an equatorial tongue with high ideal ages with AMOC slowdown during Heinrich stadial 1.

on bulk sediments and carbon isotopes ratios of benthic foraminifera have been used to infer the state of the AMOC and deep water nutrient content.

During Heinrich stadial 1, when the AMOC was substantially reduced due to meltwater input to the North Atlantic, we observe dry conditions in the Sahel and wet conditions in NE Brazil consistent with a southward displacement of the marine ITCZ. Off NE Brazil, contemporaneous changes in Pa/Th ratios and δD of plant waxes indicate that both AMOC strength and precipitation were tightly coupled over Heinrich stadial 1, with increasing precipitation during AMOC slowdown. We show that this response pattern agrees with the results of climate model simulations (Liu et al. 2009, Merkel et al. 2010), which suggests that the southward displacement of the long-term mean position of the ITCZ is directly linked to the magnitude of the AMOC slowdown.

Carbon isotope ratios measured on single shells of the benthic foraminifer *Cibicidoides* spp. show lowest values during Heinrich stadial 1 and the Younger Dryas in all cores. Generally, carbon isotope ratios are in perfect tune with Pa/Th measured on the deeper core which suggests a strong nutrient enrichment in deep- and intermediate waters during times of AMOC slowdown. At the intermediate water depth site, carbon isotope ratios during Heinrich stadial 1 reach values as low as –1 ‰. Since this extreme depletion seems to be restricted to the tropical Atlantic, we suggest that a local remineralisation of organic matter and nutrient enrichment with a sluggish circulation and/or a potential southward and downward extension of the poor-ventilated equatorial shadow zone are, at least partially, contributing to depleted values at intermediate water depths (Fig. 1).

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Dr. Stefan Mulitza
University of Bremen
MARUM – Center for Marine Environmental Sciences
Postfach 330 440
28334 Bremen
Germany
Phone: +49 421 21865536
Fax: +49 421 21865505
E-Mail: smulitza@marum.de