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SUPPLEMENTARY INFORMATION

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Muted change in Atlantic overturning circulation over some glacial-aged Heinrich events

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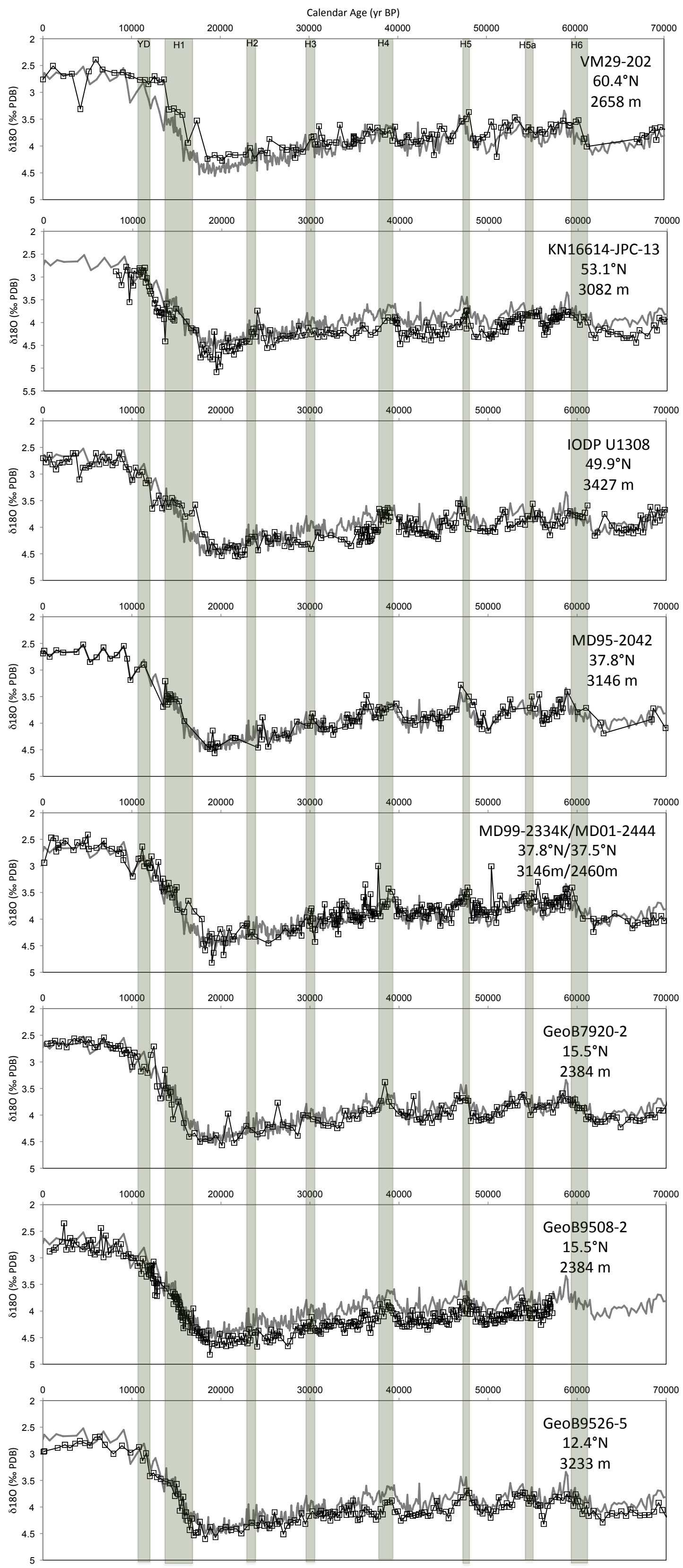
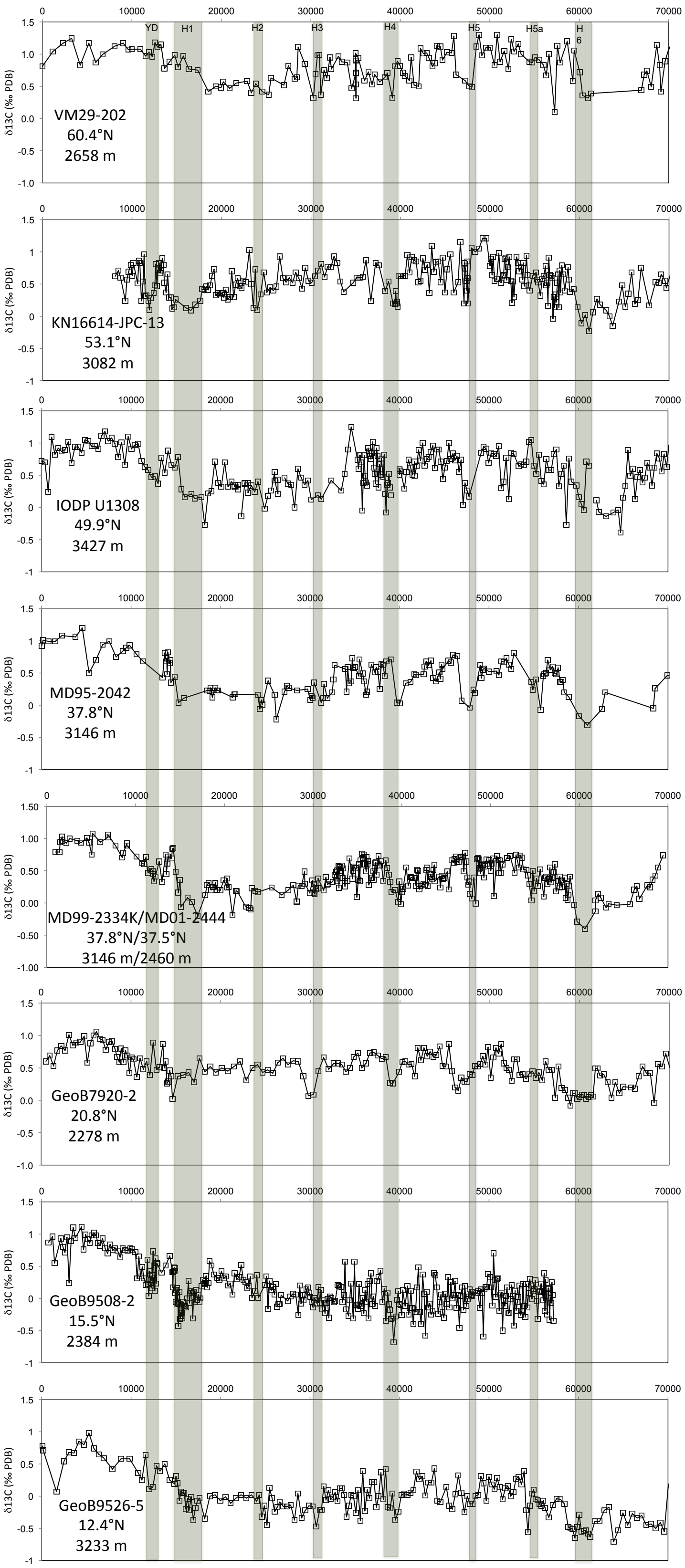
Supplemental Methods: Deep North Atlantic Carbon Isotope Stacks

Seven benthic *P. wuellerstorfi* $\delta^{13}C$ records from the deep North Atlantic were averaged to compute a stacked $\delta^{13}C$ time series for the last 80 kyr[1-8]. An additional, shorter, record[9] was used to create an eight record 40 kyr stack (Supplemental Table 2, Supplemental Figures 1-3). All records in this compilation meet or exceed an average time resolution of 500 years and are from greater than 2.2 km depth. All records were placed on a common timescale. For the upper portion of the cores, the age models were constructed using radiocarbon dates converted to calendar age using Calib 6.0 and the MARINE09 calibration data set[10]. Below the level for which radiocarbon dates were available, the age models were constrained by correlation of the *P. wuellerstorfi* $\delta^{18}O$ to the benthic $\delta^{18}O$ record from MD95-2402 using the modified Greenland ice-core age-scale (SFCP04)[11] that has been shown to be broadly consistent with the North Atlantic event stratigraphy implied by the Hulu speleothem record[12]. All records except the following two were previously published with time scales constructed in this way. For GeoB7920[6], subsequently published radiocarbon data[13] were converted to calendar age and used to constrain the age model above 300 cm depth in the core, and below 300 cm published tie points to the MD95-2042 benthic $\delta^{18}O$ record were converted to the SFCP04 timescale. For V29-202[3] radiocarbon data were converted to calendar age and used to constrain the age model above 300cm and below 300 cm the benthic $\delta^{18}O$ data was tied to the MD95-2042 benthic $\delta^{18}O$ record on the SFCP04 timescale.

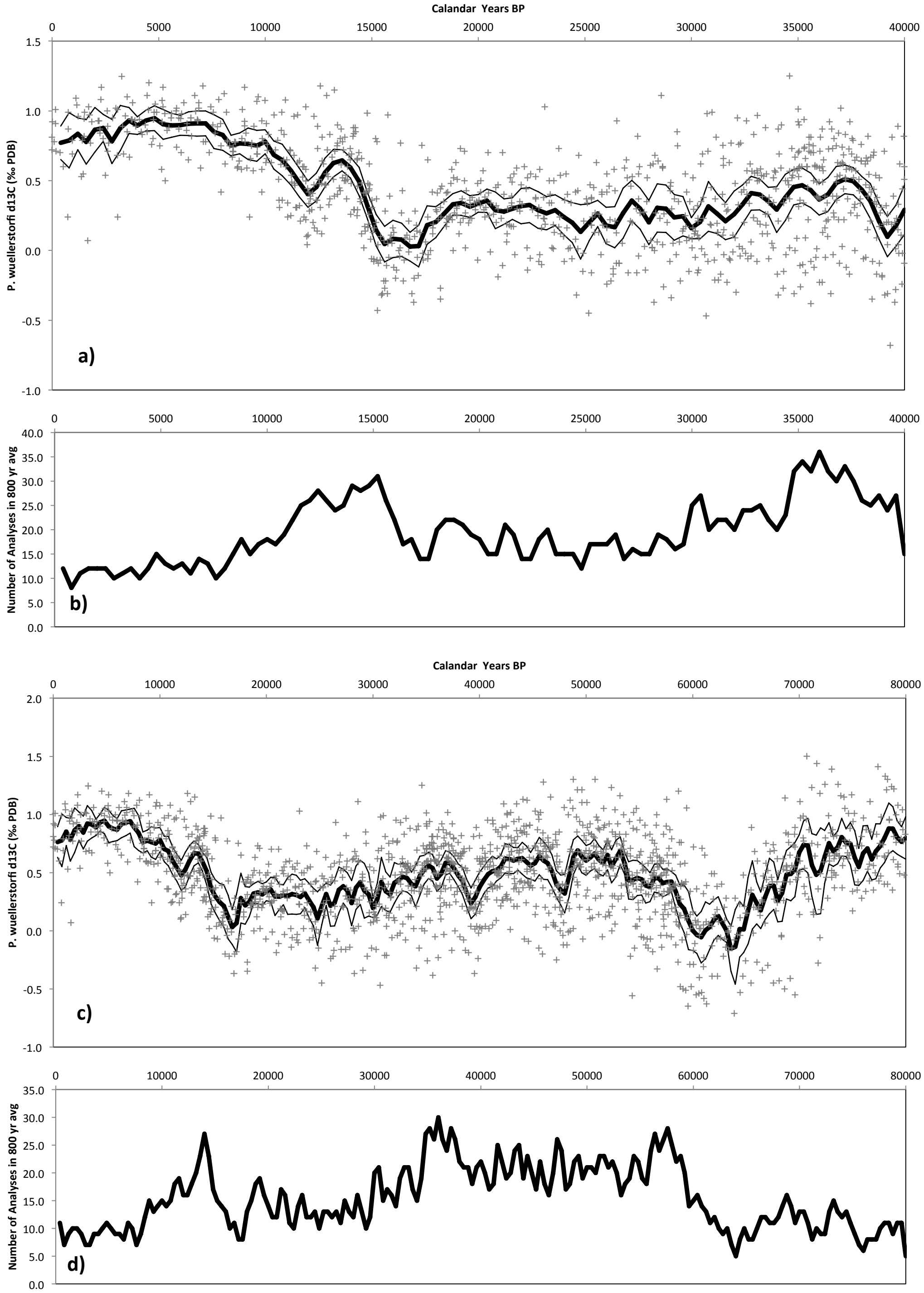


Calendar Age (yr BP)
YD
H1
H2
H3
H4
H5
H5a
H6
VM29-202
60.4°N
2658 m
KN16614-JPC-13
53.1°N
3082 m
IODP U1308
49.9°N
3427 m
MD95-2042
37.8°N
3146 m
MD99-2334K/MD01-2444
37.8°N/37.5°N
3146m/2460m
GeoB7920-2
15.5°N
2384 m
GeoB9508-2
15.5°N
2384 m
GeoB9526-5
12.4°N
3233 m
δ18O (‰ PDB)

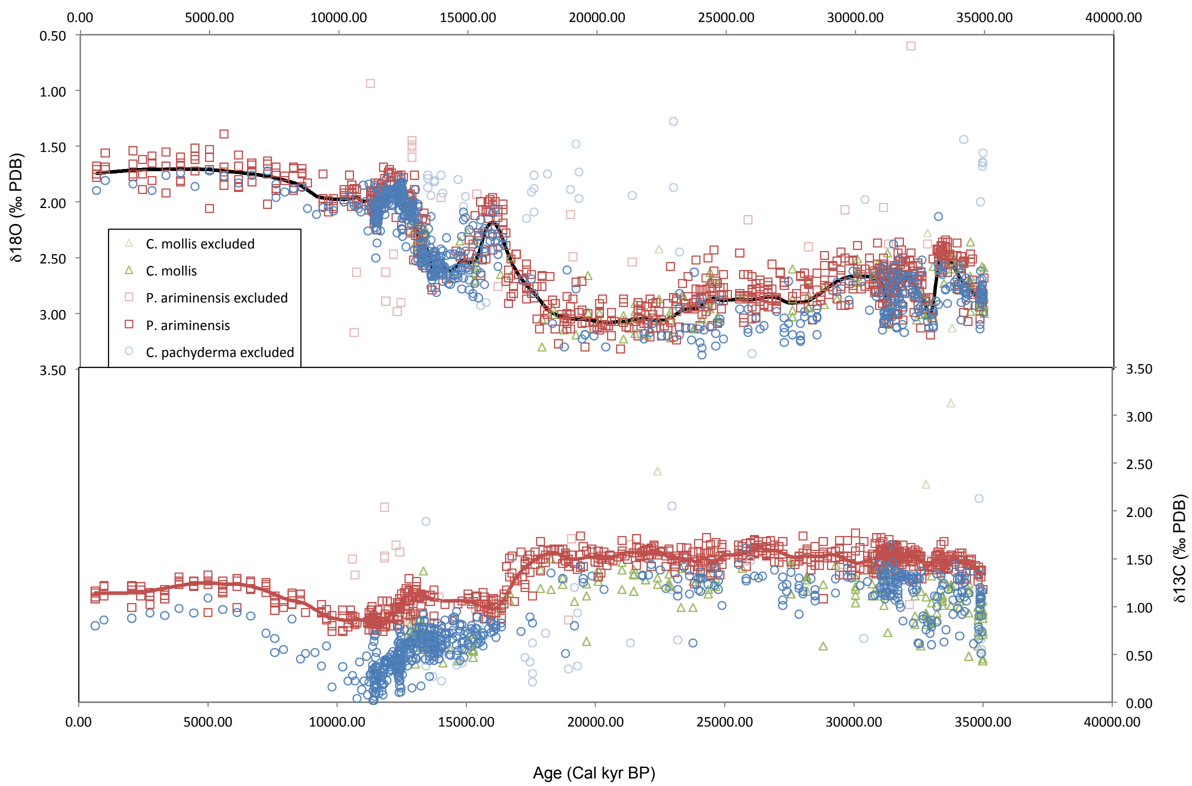
Supplemental Figure 1. Deep North Atlantic Oxygen Isotope Records. High resolution *P. wuellerstorfi* oxygen isotope records from the deep North Atlantic. The locations and sources for each record can be found in Supplemental Table 2. The time scales are constructed as described in the methods section. Grey vertical bars extending through all of the plots indicate the timing of the Younger Dryas and Heinrich stadials[14] For reference, the benthic oxygen isotope record from MD95-2042 on the SFCP04 Age scale[11] is also shown in grey in each plot.


YD
H1
H2
H3
H4
H5
H5a
H 6
δ13C (‰ PDB)
VM29-202
60.4°N
2658 m
KN16614-JPC-13
53.1°N
3082 m
IODP U1308
49.9°N
3427 m
MD95-2042
37.8°N
3146 m
MD99-2334K/MD01-2444
37.8°N/37.5°N
3146 m/2460 m
GeoB7920-2
20.8°N
2278 m
GeoB9508-2
15.5°N
2384 m
GeoB9526-5
12.4°N
3233 m

Supplemental Figure 2. Deep North Atlantic Carbon Isotope Records. The *P. wuellerstorfi* carbon isotope records from the deep North Atlantic. The locations and sources for each record can be found in Supplemental Table 2. The time scales are constructed as described in the methods section. Grey vertical bars extending through all of the plots indicate the timing of the Younger Dryas and Heinrich stadials[14].

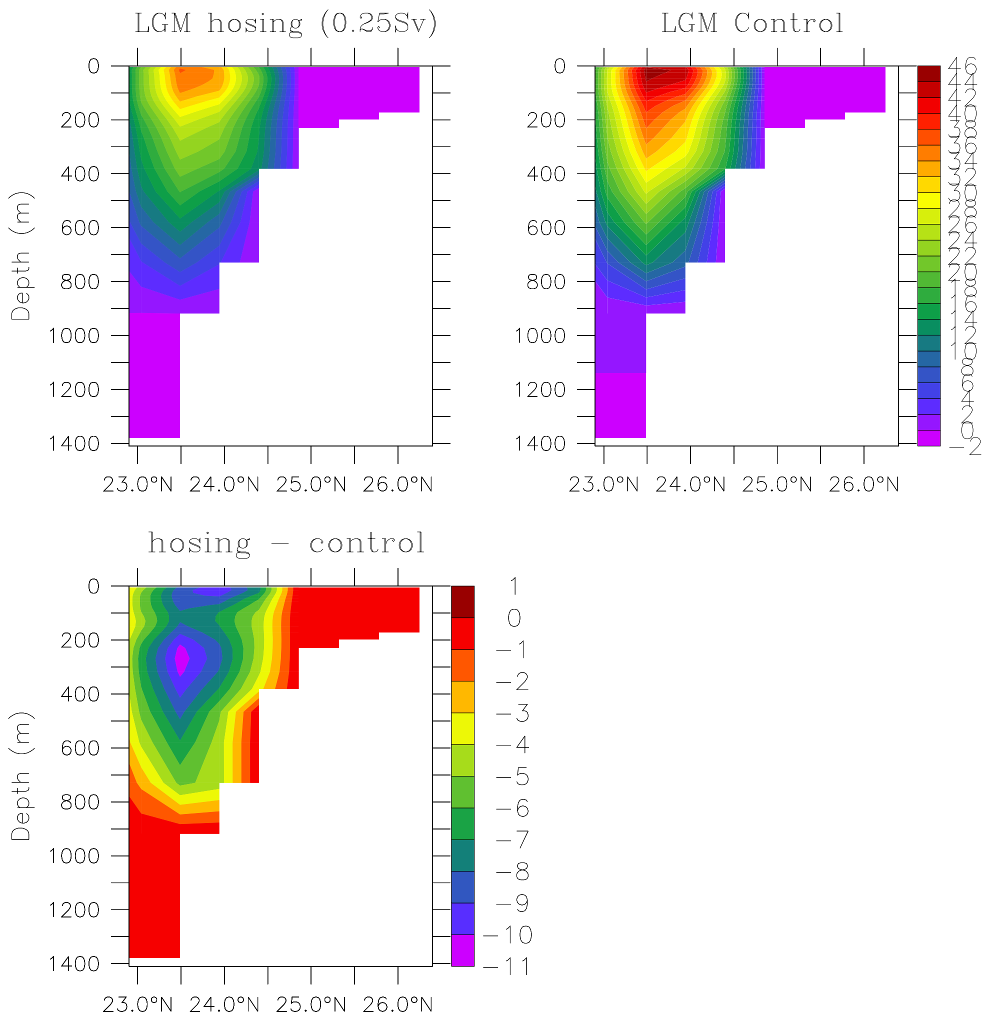


Supplemental Figure 3. North Atlantic Carbon Isotope Stack. For panels (a) and (c) the light crosses show the individual data points contributing to the 40 kyr and 80 kyr averages, respectively. The solid heavy lines are the average (800 year window) and lighter lines are +/- 2 standard error of the 800 year averages. Panels (b) and (d) show the total number of analyses contributing to each 800 year average for the 40 kyr and 80 kyr averages, respectively.

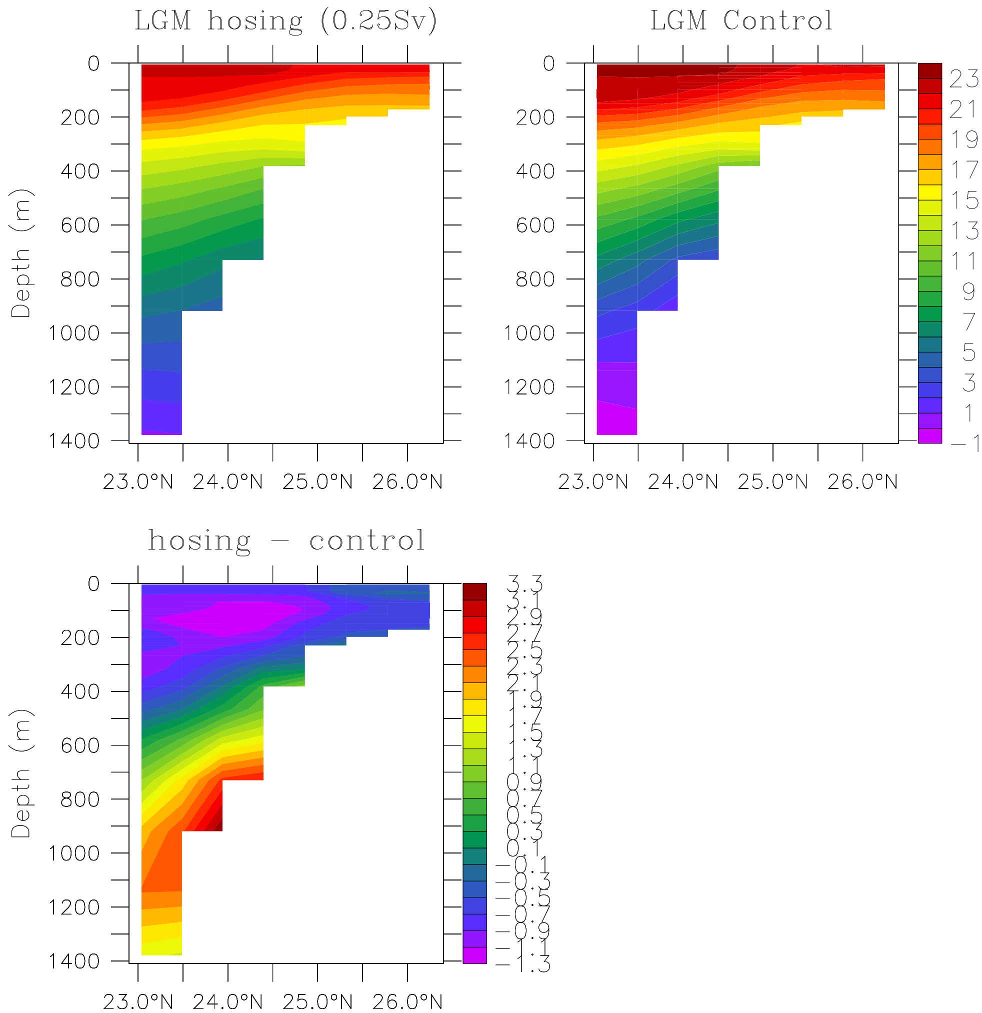


Supplemental Figure 4. Measurements on Individual Foraminifers a) δ^{18}O for individual measurements contributing to the average values at each depth shown in Figure 2. The 4% of the measurements not contributing to the averages because they have been flagged as having a distance from the robust loess smooth of the data (black line) greater than 2 standard deviations from the mean are indicated in a lighter shade. b) δ^{13}C for individual measurements. Only the data from *P. ariminensis* contribute to the depth average values shown in Figures 2 and 4.

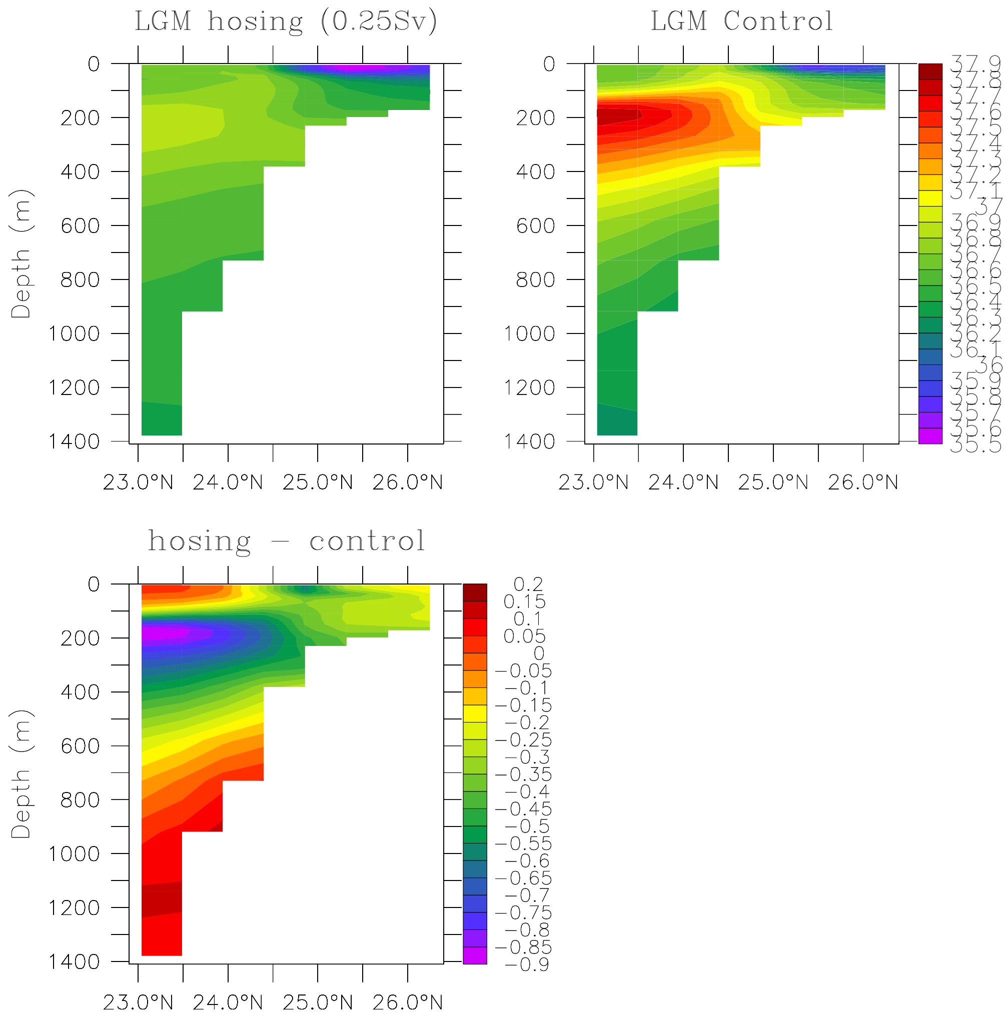
a)


LGM hosing (0.25Sv)
LGM Control
hosing − control
Depth (m)
0
200
400
600
800
1000
1200
1400
23.0°N
24.0°N
25.0°N
26.0°N
1
0
−1
−2
−3
−4
−5
−6
−7
−8
−9
−10
−11

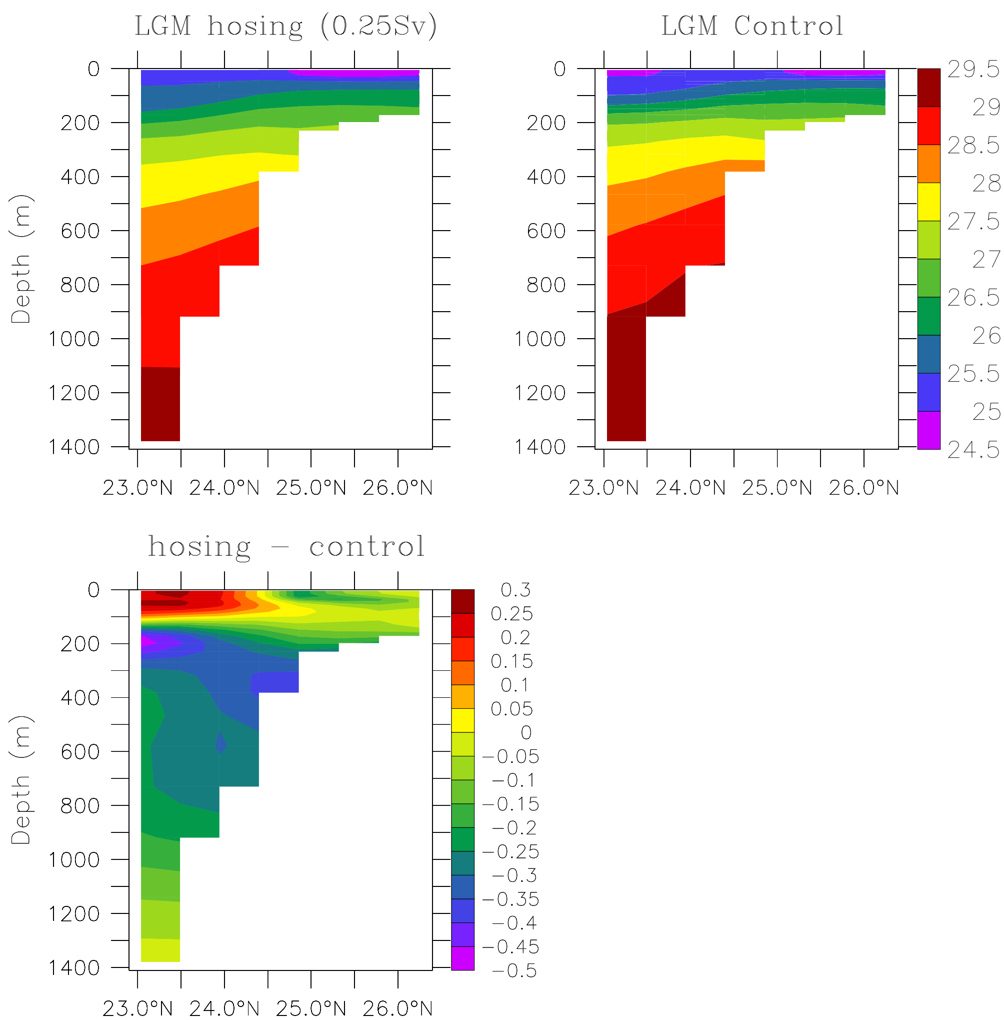
b)


LGM hosing (0.25Sv)
LGM Control
hosing − control
Depth (m)
0
200
400
600
800
1000
1200
1400
23.0°N
24.0°N
25.0°N
26.0°N
23
21
19
17
15
13
11
9
7
5
3
1
−1
3.3
3.1
2.9
2.7
2.5
2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
0.3
0.1
−0.1
−0.3
−0.5
−0.7
−0.9
−1.1
−1.3

c)


LGM hosing (0.25Sv)
LGM Control
hosing − control
Depth (m)
0
200
400
600
800
1000
1200
1400
23.0°N
24.0°N
25.0°N
26.0°N
37.9
37.8
37.7
37.6
37.5
37.4
37.3
37.2
37.1
37
36.9
36.8
36.7
36.6
36.5
36.4
36.3
36.2
36.1
36
35.9
35.8
35.7
35.6
35.5
0.2
0.15
0.1
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
−0.3
−0.35
−0.4
−0.45
−0.5
−0.55
−0.6
−0.65
−0.7
−0.75
−0.8
−0.85
−0.9

d)



Supplemental Figure 5. Florida Straits Sections along 83°W in CCSM3. For each panel the values for the LGM control run, the last 30 years of the water hosing experiment (0.25 Sv) and the anomaly (hosing – control) are shown[15]. a) velocity (cm s^{-1}) b) Temperature (°C) c) Salinity (psu) d) Sigma-theta.

Core	Depth in core	species	^{14}C age	error	Calendar Age	Source
KNR166-2 26JPC	0.75	*G. sacculifer*	1070	70	634	*Lynch-Stieglitz et al., 2011*
	48.25	*G. sacculifer*	2990	30	2760	*Lynch-Stieglitz et al., 2011*
	112.25	*G. sacculifer*	6720	40	7251	*Lynch-Stieglitz et al., 2011*
	144.25	*G. sacculifer*	8100	80	8576	*Lynch-Stieglitz et al., 2011*
	216.25	*G. sacculifer*	9550	40	10418	*Lynch-Stieglitz et al., 2011*
	280.25	*G. sacculifer, G. ruber*	10100	45	11130	*Lynch-Stieglitz et al., 2011*
	344.25	*G. sacculifer*	10000	110	10944*	*Lynch-Stieglitz et al., 2011*
	356.25	*G. sacculifer*	11750	95	13225*	*Lynch-Stieglitz et al., 2011*
	364.25	*G. sacculifer, G. ruber*	10600	70	11872*	*Lynch-Stieglitz et al., 2011*
	374.25	*G. sacculifer*	10500	50	11656*	*Lynch-Stieglitz et al., 2011*
	392.25	*G. ruber*	10850	65	12342*	*Lynch-Stieglitz et al., 2011*
	408.25	*G. sacculifer, G. ruber*	10300	60	11285*	*Lynch-Stieglitz et al., 2011*
	442.25	*G. sacculifer, G. ruber*	10700	65	12077	*Lynch-Stieglitz et al., 2011*
	464.25	*G. sacculifer, G. ruber*	10800	55	12251	*Lynch-Stieglitz et al., 2011*
	544.25	*G. sacculifer, G. ruber*	11000	65	12515	*Lynch-Stieglitz et al., 2011*
	592.25	*G. ruber*	11400	65	12866	*Lynch-Stieglitz et al., 2011*
	606.25	*G. sacculifer*	11600	35	13106	*Lynch-Stieglitz et al., 2011*
	648.25	*G. sacculifer*	12350	200	13807	*Lynch-Stieglitz et al., 2011*
	704.25	*G. ruber*	13500	55	15857	*Lynch-Stieglitz et al., 2011*
	752.25	*G. ruber*	15550	70	18271	*Lynch-Stieglitz et al., 2011*
	848.25	*G. ruber*	20300	120	23760	*Lynch-Stieglitz et al., 2011*
	878.25	*G. sacculifer, G. ruber*	21300	95	24896	this study
	952.25	*G. ruber*	26300	130	30693	*Lynch-Stieglitz et al., 2011*
	1014.25	*G. ruber*	28200	180	31890	*Lynch-Stieglitz et al., 2011*
	1032.25	*G. ruber*	28200	590	32160*	*Lynch-Stieglitz et al., 2011*
	1074.25	*G. ruber*	29300	380	33482	*Lynch-Stieglitz et al., 2011*
	1088.25	*G. sacculifer, G. ruber*	31300	200	35398*	this study
	1104.25	*G. sacculifer, G. ruber*	30600	170	34800	this study
	1118.25	*G. sacculifer*	30900	220	34958	*Lynch-Stieglitz et al., 2011*
KNR166-2 73GGC	0.25	mixed planktonics	650	35	297	*Lynch-Stieglitz et al., 2011*
	28.25	mixed planktonics	2670	30	2357	*Lynch-Stieglitz et al., 2011*
	48.25	*G. sacculifer*	3510	30	3394	*Lynch-Stieglitz et al., 2011*
	96.25	*G. sacculifer*	5040	40	5388	*Lynch-Stieglitz et al., 2011*
	152.25	*G. sacculifer*	6580	40	7102	*Lynch-Stieglitz et al., 2011*
	168.25	*G. sacculifer*	6890	45	7404	*Lynch-Stieglitz et al., 2011*
	196.25	*G. sacculifer*	9080	50	9805	*Lynch-Stieglitz et al., 2011*
	212.25	*G. sacculifer*	10550	55	11782	*Lynch-Stieglitz et al., 2011*
	224.25	*G. sacculifer*	12150	70	13592	*Lynch-Stieglitz et al., 2011*
	232.25	*G. sacculifer*	18300	90	21372	*Lynch-Stieglitz et al., 2011*
	240.25	*G. ruber*	21100	95	24691	this study
	248.25	*G. sacculifer*	22900	130	27255	*Lynch-Stieglitz et al., 2011*
	266.25	*G. sacculifer*	29300	140	33435	this study
	280.25	*G. sacculifer*	31000	190	35019	*Lynch-Stieglitz et al., 2011*
	296.25	*G. sacculifer*	36800	350	41474	*Lynch-Stieglitz et al., 2011*
	356.25				63000	*MIS 3/4 boundary*
	372.25				73000	*MIS 4/5 boundary*

Radiocarbon dates calibrated using Calib 6.0 and Marine09 curve
*Not used in age model

Supplemental Table 1. Age Control Points

Core	Longitude			Latitude			Depth (m)	Reference
GeoB9508-5	17 °	57	W	15 °	30	N	2384	Mulitza et al., (2008)
MD99-2334K	10 °	10	W	37 °	48	N	3146	Skinner et al (2007)
MD01-2444	10 °	8	W	37 °	33	N	2460	Skinner et al (2007)
IODP U1308	24 °	14	W	49 °	53	N	3883	Hodell et al. (2008)
VM29-202	20 °	58	W	60 °	23	N	2658	Oppo and Lehman (1995)
KN166-14-JPC-13	33 °	32	W	53 °	3	N	3082	Hodell et al. (2010)
MD95-2042	10 °	10	W	37 °	48	N	3146	Shackleton et al. (2000)
GeoB7920-2	18 °	35	W	20 °	45	N	2278	Tjallingi et al. (2008)
GeoB9526-5	18 °	3	W	12 °	26	N	3233	Zarriess and Mackensen (2011), Zarreiss (2010)

Supplemental Table 2. Sediment Core Locations and Sources for Carbon Isotope Stack.

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