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Methods

Ocean sediment core OCE326 GGC14 is located on the Laurentian Fan along the western edge of the Gulf Stream track (43.03º N, 55.49º W, 3525 m. water depth). The Laurentian Fan experiences high sedimentation rates (~40 cm yr^{-1} from ~17.4 to 10.0 ka), producing high-resolution records that can record millennial and centennial scale climate events (Keigwin and Jones, 1995; deVernal et al., 1996; Keigwin et al., 2005; Carlson et al., 2007). Core GGC14 has a ^{14}C chronology based on 7 planktonic reservoir-corrected, calibrated ^{14}C dates (Keigwin et al., 2005) and the well-established $\delta^{18}O$ stratigraphy for the Laurentian Fan (30 ^{14}C dates) (Keigwin and Jones, 1995). Samples were selected at regular ~2 cm intervals, resulting in an average ~100 yr sample resolution from 10 ka-17.4 ka. However, we focus on the interval ~13.1-17.4 ka, with ~65 yr resolution during this period, because of a higher sample frequency.

Samples were dried and washed using procedures similar to Miller et al. (1991) in the Micropaleontology Lab at the University of Wisconsin-Madison. A 5% calgon solution was used to wash and disaggregate. The samples were sieved to isolate >63 μm sediment fraction. Approximately 25 foraminifera from each sample were picked from the 150 to 250 μm size fraction. Mg/Ca ratios were measured using the continuous flow-through method of Klinkhammer et al. (2004) at the College of Oceanic and Atmospheric Sciences W.M. Keck Laboratory for Plasma Spectrometry, Oregon State University. The flow-through method measures the continuous dissolution of the foraminifera, mimicking the dissolution that occurs on the seafloor (Benway et al., 2003), and detects the presence of over-growths that may bias Mg/Ca temperature estimates (Haley and Klinkhammer, 2002). This method removes the overgrowth contaminant phase from the shell, and provides a way to minimize any ecological or dissolution effects on the Mg/Ca ratio (Klinkhammer et al., 2004). We note that the core depth of GGC14 of 3525 meters is above the lysocline of the North Atlantic and that the influence of dissolution on foraminifera test Mg/Ca in the North Atlantic is only detectable below a depth of ~4000 m (Carlson et al., 2008). The flow-through method also allows for the isolation of the clay contaminant-phase. Clay has a Mg/Ca ratio ~1000 times higher than that of biogenetic calcite, which could lead to a falsely high trace element ratio (Benway et al., 2003; Klinkhammer et al., 2004). The flow-through method provides for higher resolution data than the batch method (Boyle, 1981; Boyle and Keigwin, 1985; Barker et al., 2003) by using time resolved analysis, which takes 85 measurements per sample rather than just one measurement (Benway et al., 2003; Klinkhammer et al., 2004).

Mg/Ca ratios were converted to calcification temperature (CT) using the calibration for *Neoglobogerina pachyderma* sinistral (s) of Mashiotta et al. 1999, based on North Atlantic core top samples (Nürnberg, 1995):

$$Mg/Ca = 0.549e^{(0.099CT)} \qquad (1)$$

The effects of continental ice volume were removed (Clark and Mix, 2002) from the existing *N. pachyderma* (s) δ^{18}O of calcite record (Keigwin et al., 2005) and the δ^{18}O of seawater ($\delta^{18}O_{sw}$) was calculated using CT and δ^{18}O following Bemis et al. (1998):

$$\delta^{18}\mathrm{O}_{sw} = \frac{(\mathrm{CT} - 16.5) + 4.8(\delta^{18}\mathrm{O}_{calcite})}{4.8} + 0.27 \qquad (2)$$

CT-error was calculated with respect to both reproducibility and calibration error. The flow-through method has an average standard deviation of 0.08 mmol/mol (±3%) of Mg/Ca ratios in duplicate samples (Klinkhammer et al., 2004). Including the temperature calibration error (±10%; Mashiotta et al., 1999), the propagated uncertainty of absolute temperature is ±11%

after considering the individual effects of each on temperature (i.e., temperature changes only have a 10% effect on foraminifera Mg/Ca) (Bevington and Robinson, 2003). After including the reproducibility of $\delta^{18}O$ of calcite (±5%, Keigwin et al., 2005), the propagated absolute uncertainty for $\delta^{18}O_{sw}$ is ±13%. However, the relative uncertainty for $\delta^{18}O_{sw}$, when comparing samples from the same core, reduces to ±8% because the error in the temperature calibration is the same for each sample. We note the agreement between early Holocene Mg/Ca ratios from adjacent core 26GGC (Keigwin et al., 2005) and GGC14, which are within the reproducibility of the measurements. The effects of salinity on foraminifera Mg/Ca are not considered, because the salinity effect is less than temperature on Mg/Ca and appears to only have a significant impact in high salinity environments (Lea et al., 1999; Ferguson et al., 2008; Kisakürek et al., 2008). We do, however, acknowledge the potential unaccounted for effects of salinity on Mg/Ca.

We use a freshwater-ocean mixing model to calculate the amount of runoff from eastern North America that is required to explain the decreases in $\delta^{18}O_{sw}$ (δ_s) during the Bølling/Allerød (Aharon, 2003; 2006; Carlson et al., 2007; Carlson, 2009). The δ_s is calculated as Eqn. (3):

$$\delta_s = \frac{f_o \times \delta_{o-x} + f_{r-x} \times \delta_r}{f_o + f_{r-x}} \tag{3}$$

where $f_{r\text{-}x}$ (Sverdrups, 1 Sv = 10^6 m^3 s^{-1}) is the flux of runoff and δ_r its $\delta^{18}O$, and f_o (Sv) is the flux of ocean water (Sv) and $\delta_{o\text{-}x}$ the ocean $\delta^{18}O$, at time step x (x = 1 for pre-δ_s decrease, x = 2 for during the δ_s decrease). Eqn. (4) is used to determine the $\Delta\delta^{18}O$:

$$\Delta\delta^{18}O_{sw} = \delta_{s-2} - \delta_{s-1} \tag{4}$$

with subscripts *s-2* and *s-1* indicating the δ_s during (x = *2*) and before (x = *1*) $\delta^{18}O_{sw}$ decrease. Eqn. (3) and (4) are solved so that the solution to Eqn. (4) matches the observed $\Delta\delta^{18}O_{sw}$ in the records. The increase in f_{r-2} relative to f_{r-1} is then calculated as the increase in terrestrial runoff through the Hudson and St. Lawrence Rivers.

End-member fluxes (f) and $\delta^{18}O$ (δ) are taken from the literature. δ_r is derived from $\delta^{18}O$ measurements in Lake Huron that show a constant ~-11.5 ‰ of Great Lakes water during the Bølling/Allerød (Lewis and Anderson, 1992). The δ_r records only extend back to the onset of the Bølling not allowing an assessment of the earlier freshwater discharge events. δ_{o-x} changes with the gradual decrease in ocean $\delta^{18}O$ across the last deglaciation and an appropriate value is used for the given time following Clark and Mix (2002). The ocean flux (f_o) is calculated at ~0.74 Sv, which is the net flux of ocean water to the core site below 100 m water depth (Dickie and Trites, 1983). This water exits in the upper 100 m mixed layer, the depth habitat of *N. pachyderma* (s). We note that during the Bølling/Allerød the bathymetry of the core site was not significantly different from present because isostatic rebound and sea level rise were approximately in step for this region (Shaw et al., 2002). We thus assume that the present f_o was roughly the same during the Bølling/Allerød.

We estimate the error in our model results using the ±8% uncertainty in relative changes in $\delta^{18}O_{sw}$ (note that using the ±13% absolute uncertainty does not significantly change the model error). An unaccounted error in our model results is the assumption of a constant ocean flux (f_o). However, to meet the requirement that the region below 100 m water depth is filled with water, past changes in (f_o) must have been small (i.e., <5%) and accounting for this effect does not significantly affect model discharge results (<0.001 Sv).

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Table DR1. Data from core GGC14. Age scale and $\delta^{18}O$ are from Keigwin et al. (2005). CT is calculated following Mashiotta et al. (1999).

Depth (cm)	Age (ka)	$\delta^{18}O$	Mg/Ca	CT	$\delta^{18}O_{sw}$
119.5	10.02	2.46	1.36	9.17	0.87
139.5	10.67	2.33	1.32	8.85	0.60
160.0	11.33	2.3	1.23	8.11	0.38
170.5	11.66	2.265	1.21	-	-
178.5	11.92	2.425	1.14	-	-
201.5	12.71	2.58	1.10	-	-
210.0	12.95	2.8	1.00	-	-
210.5	12.97	2.805	0.98	-	-
213.5	13.10	2.87	0.97	5.73	0.26
216.0	13.16	2.95	0.97	5.71	0.33
216.5	13.17	2.95	0.96	5.60	0.31
219.5	13.30	2.74	0.92	5.23	0.01
220.0	13.32	2.74	0.91	5.15	0.00
223.5	13.43	3.12	0.83	4.18	0.25
228.0	13.56	3.09	0.92	5.19	0.42
229.5	13.63	2.76	0.91	5.13	0.07
232.0	13.69	3.27	0.96	5.62	0.67
233.0	13.73	3.19	0.97	5.74	0.61
233.5	13.76	2.96	0.89	4.87	0.20
235.0	13.79	2.72	0.90	5.02	-0.02
236.0	13.82	3.09	0.92	5.16	0.38
239.5	13.90	2.97	1.00	6.06	0.44
243.5	13.97	3.22	0.93	5.28	0.51
247.5	14.05	3.27	1.15	7.44	1.00
251.5	14.12	2.81	0.98	5.81	0.19
252.5	14.14	2.88	0.86	4.56	0.00
253.5	14.16	3.06	1.00	6.06	0.48
254.0	14.18	3.06	0.98	5.81	0.43
255.5	14.20	3.28	1.02	6.30	0.75
256.5	14.21	2.9	0.93	5.37	0.17
257.5	14.23	3.07	0.92	5.16	0.29
258.5	14.24	3.07	0.99	5.94	0.45
259.5	14.26	3.32	1.00	6.04	0.72
263.5	14.32	3.44	0.98	5.86	0.79
267.5	14.38	3.37	1.07	6.78	0.90
271.5	14.43	3.32	1.16	7.55	1.01
276.0	14.49	3.26	1.09	6.92	0.81
279.5	14.55	3.48	1.18	7.69	1.19
281.0	14.56	3.45	1.21	8.01	1.22
281.5	14.57	3.29	1.08	6.79	0.81
282.5	14.58	3.08	1.11	7.09	0.66
283.5	14.61	2.79	1.21	7.98	0.55
284.5	14.62	2.68	1.03	6.38	0.11
285.5	14.63	2.91	1.06	6.60	0.38
286.5	14.64	2.91	0.98	5.82	0.22
300.5	14.84	3.49	0.96	5.62	0.75

304.5	14.90	3.4	0.99	6.00	0.73
312.5	15.02	3.51	0.91	5.12	0.65
316.5	15.08	3.56	0.90	5.03	0.68
324.5	15.19	2.93	0.89	4.83	0.00
331.5	15.31	3.16	0.91	5.10	0.29
339.5	15.43	3.35	0.86	4.47	0.34
347.5	15.54	3.26	0.76	3.25	-0.01
363.5	15.79	3.02	0.82	4.05	-0.10
372.5	15.96	2.57	0.95	5.54	-0.25
374.5	15.99	2.43	0.91	5.13	-0.47
376.5	16.04	2.42	0.92	5.20	-0.47
378.5	16.08	2.3	1.09	6.88	-0.24
383.5	16.17	3.07	0.85	4.46	0.02
391.5	16.33	3.13	0.80	3.79	-0.07
399.5	16.48	3.35	0.76	3.30	0.04
407.5	16.64	3.61	0.71	2.63	0.15
410.5	16.67	3.63	0.73	2.85	0.22
414.5	16.75	3.56	0.72	2.68	0.11
418.5	16.83	3.55	0.73	2.85	0.13
423.5	16.92	3.53	0.72	2.70	0.08
426.5	16.98	3.528	0.82	4.08	0.36
427.5	17.02	3.42	0.81	3.88	0.21
430.5	17.06	3.525	0.70	2.38	0.00
434.5	17.14	3.705	0.71	2.60	0.22
438.5	17.21	3.72	0.68	2.15	0.14
446.5	17.37	3.62	0.63	1.42	-0.12
447.5	17.41	3.61	0.59	0.66	-0.29