GC21A CC: 220 C-E Tuesday 0830h

Impact of Ice Surges and Major Drainage Events on Thermohaline Circulation and Climate: Geologic Records and Numerical Simulations IV Posters *(joint with OS, C)*

Presiding: **D C Barber,** Bryn Mawr College**; A de Vernal,** Universit du Qubec Montral

GC21A-01 0830h POSTER

Large-scale Ice Discharge Events in a Pure Ice Sheet Model

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Sediment cores in the North Atlantic show evidence of periodic large-scale ice discharge events between 60 ka and 10 ka BP. These events occurred with a typical period between 5 kyr and 10 kyr. During each event, a significant amount of ice was discharged from the Hudson Bay region through the Hudson Strait and into the North Atlantic. This input of freshwater through the melting of icebergs is thought to have strongly affected the Atlantic thermohaline circulation. One theory is that these periodic ice discharge events represent an internal oscillation of the ice sheet under constant forcing. A second theory requires some variable external forcing on an unstable ice sheet to produce a discharge event. Using the ice sheet model of Marshall, an attempt is made to simulate periodic large-scale ice discharge events within the framework of the first theory. In this case, ice sheet surges and large-scale discharge events occur as a free oscillation of the ice sheet. An analysis of the activation of ice surge events and the thermodynamic controls on these events is also made.

GC21A-02 0830h POSTER

Heinrich Events / DC Layers: Benthic Foraminiferal Evidence of Changes in Bottom-Water Characteristics and Circulation During Periods of Rapid Deglaciation

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Sudden, large-volume iceberg influxes into the Atlantic Ocean during deglacial episodes throughout the Wisconsinan are inferred by the presence of Heinrich Events (HE), sediment layers with abundant ice-rafted detritus (IRD). In the western North Atlantic, from Cumberland Sound south to Newfoundland, cores contain IRD layers composed predominantly of detrital carbonate (DC), the result of grounded ice eroding Paleozoic carbonate bedrock flooring Hudson Strait and areas of the Canadian Continental Margin. There is a strong to coincident correlation between most HE and DC layers; both contain a marked drop in the abundance of planktic foraminiferal tests, due to both increased sedimentation rates and reduced sea-surface salinities. Evidence indicates that some HE / DC layers correlate to known periods of meltwater influx, and the youngest HE / DC layer correlates to meltwater outflow from glacial Lake Agassiz through Hudson Strait, a massive outburst as the Laurentide Ice Sheet over Hudson Bay underwent final collapse, disrupting thermohaline circulation throughout the North Atlantic. Evidence for changes in the characteristics and circulation of bottom waters are found in the benthic foraminiferal faunas, and they have been utilized to determine more about the bottom-water changes during periods of rapid deglaciation. In a sampling of two shelf and two upper slope areas (all with at least one C-14 AMS date), short-lived, sharp-boundaried increases in the occurrences of deglacial benthic foraminiferal species, species known to tolerate reduced salinities, appear, indicating that either the meltwater flux extended throughout the water column, or that meltwater volumes were large enough to reduce bottom-water salinities when meltwater mixed with the water mass. In the northern Labrador Slope core (97-16), 3 DC layers are present (DC1, DC2, DC3) and deglacial foaraminferal assemblage (DFA) sequences show a strong correlation to the DC layers. In the Notre Dame Channel (Outer Northeast Newfoundland Shelf) core (83-7) three DC layers (DC-1, DC0, DC1) are present. Icebergs / meltwater from Hudson Strait (including Lake Agassiz) flowed south above the upper slope during DC-1 and DC0, forcing displacement of slope bottom waters and their coincident faunas into the basins of the outer shelf, followed by meltwater mixing, and DFA sequences replacing the slope species. In the Flemish Pass (Newfoundland Slope) core (99-4), 7 DC layers are present, including DC layer 5a; DFA sequences are associated with DC1, DC2, and DC3, and the faunas between HE / DC layers are glacial in nature. However, prior to DC3, there were very different faunas present, indicating major changes in bottom-water characteristics and circulation after DC3. Faunas prior to DC3 were dominated by a few species found rarely living today in the slope sediments of the continental margin. At the Halibut Channel site (western Grand Banks) (core 87B-2) there is good chronological control, the DFA sequences occur at H0, H1, and H2. Benthic foraminifera aid in determining bottom-water characteristics and circulation; and the interaction between bottom and surface waters during periods of rapid deglaciation.

GC21A-03 0830h POSTER

Abrupt Sea Level Oscillations During Pleistocene Highstands: Results From a Novel High-Resolution Approach to Coral Sea-Level Reconstruction

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Fluctuations in past sea level are a sensitive indicator of global climate change. Our knowledge of such changes is derived from two sources: the changing oxygen isotope composition of seawater and the ages and elevations of corals that grew near the sea surface. These two proxies have been used over the last 30 years to develop a broad understanding of sea-level change over glacial/interglacial cycles. Oscillations in sea level have been linked to variations in the earth's orbit with a minimum periodicity of about 21,000 years. While there is ample evidence for climate oscillations that are too frequent to be explained by orbital forcing, evidence of sub-orbital frequency sea-level change is just beginning to emerge, primarily due to problems with U/Th coral dating. Here we use a new approach to coral dating that corrects ages for the frequently observed open-system behavior of U-series isotopes. A sea-level curve, recalculated from published Barbados coral data, suggests that sub-orbital frequency sea fluctuation may be a persistent feature of the sea-level record.

GC21A-04 0830h POSTER

Paleointensity of the Western Boundary Undercurrent since the Last Glacial maximum from ^{230}Th excess-changes in deep Irminger Sea sediments.

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In the present study we determined ^{230}Th excesses in cored sediments raised from the SE Greenland lower slope (core HU91-45-52), as a mean to document changes in the intensity of the Western Boundary Undercurrent (WBUC) which carries NADW water masses out of the Irminger Basin. In order to calculate initial ^{230}Th excesses (^{230}Th$_{xs}$)$_0$ in sediment the ^{230}Th fraction produced in situ and the excess ^{230}Th decay since deposition must be established. This requires an estimate of the detrital and early diagenetic fractions of the uranium present. Here, we tried to improve the usual method to estimate the detrital fraction that is based on ^{232}Th contents and a constant U/Th ratio in the carrier particles. However, this ratio reveals grain size-dependent. The relationship between grain-size of detrital particles and their U and Th isotope composition has been examined from independent measurements in 5 grain-size fractions (0-2 ; 2-10; 10-30; 30-63; >63 μm) from box-cored surface sediments. As could have been expected, ^{232}Th and ^{230}Th activities increase in the clay fraction (<2 μm). The quantitative relationship determined between grain-size and ^{238}U/^{232}Th Activity Ratio (AR) has then been used to reconstruct ^{238}U/^{232}Th AR in older sediments, estimated to be equal to the weighted sum of ^{238}U/^{232}Th AR in detrital fractions of each sample. Results from the study core show that at approximately during the last glacial/interglacial transition, diagenetic U content represented between 16 and 79 % of the total uranium content. This diagenetic U was taken into account for the calculation of the ^{230}Th$_{xs}$ since the Last Glacial Maximum (LGM) assuming that the U-uptake occurred within a short time interval following sedimentation. The subsequent reconstructed ^{230}Th$_{xs}$ fluxes highlight a migration of the WBUC from its deeper LGM setting to its modern situation, and its increasing outflow in relation to the enhancement of the Denmark Strait Overflow Water (DSOW), at approximately 6.5 ka . The WBUC reaches a maximum outflow at 2.5 ka approximately and its intensity decreases since this time.

GC21A-05 0830h POSTER

Mudwaves on the South Gardar Drift: North Atlantic

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The development of mudwaves on the southern Gardar Drift (eastern N. Atlantic- Kn166-14 cruise in August 2002) has been studied using gravity and jumbo piston cores samples in combination with swath mapping bathymetry and 3.5 kHz and multi-channel seismics. Swath mapping along the crest of the south Gardar Drift (14,391 km2) shows a highly complex nature to these mudwaves. West of the main drift, mudwave orientations are governed by the location of secondary crest spurs that trend roughly E-W. Individual mudwaves can be traced across the main drift crest, making an elongated "S" pattern with mudwave orientation predominantly perpendicular to the drift crest. Statistical analyses of the mudwaves were done to determine slope asymmetry and orientations to regional bathymetry for this section of the Gardar Drift. Mudwave orientations that are greater than 20o to the regional contours show asymmetric development and located at depths of less than 3200 m. These asymmetric mudwaves show up slope migration and have crest orientations that are counter-clockwise from the regional contours. This suggests that there may be some cross drift bottom current flow governing their development. Well-developed migrating mudwaves are located north of the western spur and west of the main Gardar Drift crest. Jumbo piston cores taken on each side of a particularly well-imaged mudwave show differential sedimentation rates that clearly indicating that the mudwave has migrated upslope for the last 150 kyr. Using initial shipboard stratigraphy, sediment rate ratios determined from the core and Flood's (1988) lee wave model, a paleoflow history for this mudwave was determined. Circa 130 kybp bottom flows were sluggish and increased to about 12 cm/s over the next 30 kyr. Around 100 kybp the currents increased again, averaging 16 cm/s. Bottom current speeds have fluctuated between 14 and 17 cm/s for the last 100 k yrs. Isotope stratigraphy and grain size analyses will refine the timing and speed of this bottom current variability.

GC21A-06 0830h POSTER

Evidence for Millennial-Scale Climate Variability in the Surface Waters Above ODP Site 980, NE Atlantic Ocean During the Last Glacial Interval (MIS 4-2)

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Successful efforts to recover quality high sedimentation rate deep-sea sediment sections from the North Atlantic over the last decade have produced a number of studies demonstrating that climate instability at sub-orbital and even millennial time-scales is a pervasive component of Late Pleistocene North Atlantic climate. This is particularly true during Marine Isotope Stages (MIS) 4-2, i.e., the last glacial interval. One such high sedimentation rate section was recovered at ODP Site 980, Northeast Atlantic Ocean where sedimentation rates during MIS 4-2 exceed 15cm/kyr. Recently, we have begun to generate more detailed records from MIS 4-2 at Site 980 by reducing our sampling interval from 20 to around 2.5 cm, improving the resolution of our records an order of magnitude, from 1200-1300 to 100-200 years. 300 samples were used to generate high resolution records of changes in the input of ice-rafted detritus (IRD), along with limited data documenting changes in the relative abundance of the N. pachyderma, left coiling, which can be evaluated within the context of our previously generated lower resolution planktic and benthic oxygen isotope records used to generate our age model for this interval. Our previously published low resolution IRD record enabled us to identify Heinrich events 1-6 within the sediment interval deposited during the last glacial. Each event is characterized by IRD concentrations ranging from 500 to over 2500 lithic grains >150 microns per gram sediment. Superimposing our new high resolution IRD record reveals that Heinrich events 3,2,1 occurring at approximately 32, 23, and 17 kya, respectively, are each composed of a series of separate abrupt rapid increases in IRD concentrations approaching 1,000 grains per gram. An additional comparable event occurring at approximately 20 kya has also been identified. In the early part of the last glacial H6, H5, and H4 occurring at approximately 66, 47, and 38 kya, respectively, are recorded as much more abrupt and rapid increases in IRD concentrations to 2,000 or greater lithic grains per gram than were observed in our previous record. There are two 5 kyr intervals between H6 and H5 that contain little or no IRD. An additional abrupt IRD event is recorded at approximately 34 kya. Thus, our new IRD record is recording a series of additional episodic increases in IRD concentrations comparable in intensity to the identified Heinrich events. This suggests that ODP Site 980 sediments are recording a series of more closely spaced episodic increases in IRD concentration that can be directly related to the Dansgaard/Oeschger events recorded in Greenland ice cores. Comparison of our preliminary high resolution record of changes in the relative abundance of the polar species N. pachyderma, left coiling, to our IRD record suggests that the input of iceberg bearing waters precedes the increases in the relative abundance of N. pachyderma, left coiling for the early glacial IRD events. Whereas the abrupt increases in N. pachyderma, left coiling seem to occur during the later glacial IRD events. Thus, in the early glacial the influx of icebergs seem to occur before the invasion of cooler surface waters as opposed to the same time later in the glacial.

GC21A-07 0830h POSTER

Paleoprecipitation reconstruction in the Rhine Valley over the last glaciation: application of inverse modeling using isotopic record

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Carbon isotopic record performed on loess organic matter in Nuloch (Rhine Valley, Germany) is used as constraint for paleoprecipitation reconstruction by inverse modeling with Biome4. Loess deposits constitute ideal terrestrial archive to study paleoclimate during the glaciations since they deposit very quickly, are associated with sparse vegetation with weak rhizosphere and are not prone to pedogenesis. That maintains some laminated structures and especially preserves the memory of the contemporary climatic conditions at the deposit. The isotopic composition recorded by loess organic matter reflects nicely the original isotopic signature of vegetation. The Nussloch loess section profits from a fine and reliable chronology based on 14C and OSL. Previous geochemistry studies showed that during the last climatic cycle, Nussloch knew vegetation with the single presence of C3 plants. d13C changes can thus be interpreted as changes in environmental conditions: mainly atmospheric CO2 concentration and isotopic composition and precipitation and secondarily, temperature, soil type and texture, insolation. . . . We present here additions inserted in Biome4 model for the simulation of the mean d13C of plant communities and its application as inverse modeling using the Metropolis-Hastings technique to the Nussloch sequence. Paleoprecipitation reconstruction is carried out over the 15-70 kyr cal BP period. It exhibits an annual mean level of ca 400mm.yr-1, with a minimum of ca 200 mm.yr-1 around 27 and 56 kyr cal BP and a maximum of ca 600 mm.yr-1 around 50 kyr cal BP. Abrupt events (pluri-centennial scale), marked by positive or negative excursions, reaching 200mm.yr-1 are noted. Correlation with ice cores Dansgaard-Oeschger events and deep sea cores Heinrich events is discussed.

GC21A-08 0830h POSTER

North American Freshwater Forcing of the Last two Abrupt Climate Events

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North American freshwater routing played an important role in reducing Atlantic thermohaline circulation and causing abrupt climate change during the last deglaciation. Proxies of these events are difficult to interpret, however, owing to competing controls on a single proxy that may obscure a clear signal of salinity changes. Here we describe changes in the ocean-concentration dependent ratio of U, and C (δ^{13}C) and Sr (^{87}Sr/^{86}Sr) (preliminary) isotopes in planktic foraminifera from the St. Lawrence Seaway that occur during the Younger Dryas (YD) and from Hudson Strait during the 8.2 ka cold event. Observed changes are evaluated against a geochemical river-estuary model to determine the source and flux of freshwater during these events. U is sourced mainly from shale and Cretaceous-Tertiary rocks of the Canadian Plains, while Sr isotopes reflect terrain age (the western Canadian Shield is 1 Gyr older than the eastern Shield) and more negative δ^{13}C reflects the influence of freshwater. During the YD, our St. Lawrence samples identify an increase in U concentration and Sr isotopes and a decrease in δ^{13}C, suggesting an increase in freshwater from the Canadian Plains, an increase in terrain age of the freshwater source region, and a greater freshwater influence. These data are consistent with retreat of the Laurentide Ice Sheet (LIS) and routing of western North American water to the St. Lawrence. A subsequent decrease in these proxies at the end of the YD implies a readvance of the LIS and rerouting of freshwater away from the St. Lawrence. Similarly, U increased and δ^{13}C decreased during the 8.2 ka cold event, consistent with collapse of the LIS and routing of Canadian Plains water to Hudson Strait. Results agree with geochemical model predictions which suggest base flow discharges of 0.15-0.25 Sv during the YD and 0.17 Sv during the 8.2 ka cold events.

GC21A-09 0830h POSTER

Estimating the Climatic Impact of an Early Holocene Meltwater Event Around the Gulf of St. Lawrence

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An early Holocene episode of meltwater drainage from the Great Lake region through the St. Lawrence River (sometimes referred to as the Middle Stanley) was previously shown to cause important changes in sea surface temperature (SST) in Bay of Islands (west coast of Newfoundland) and a reversal in the postglacial vegetation succession along the shores of the St. Lawrence River and Gulf. The impact of this meltwater event is estimated with reconstructions of both the sea surface and the air temperatures. SST was reconstructed from dinoflagellate cyst data from core MD99-2225 using transfer functions and the GEOTOP database of modern reference sites. Air temperature was reconstructed from pollen diagrams around the Gulf of St. Lawrence, using modern data from the NAPD. Before the meltwater event (around 10,000 years ago), August SST and salinity in Bay of Island were close to their present day averages of 17°C and 32 psu. The middle Stanley meltwater phase resulted in a sharp drop in these two parameters. Between 9500 and 8600 BP, SST remained 3 to 7degree lower than the present day average, salinity, 3 to 5 psu lower. Around 9500BP, a recently established spruce forest was replaced by a birch-dominated shrub-tundra in southwest Newfoundland, as recorded in lake pollen diagram from that area, and in the of Bay of Islands core. Reconstructions based on those pollen diagram show that temperature dropped by as much as 3°C. Conifer forests developed again after 8500 BP. In pollen records from PEI and NB, the dominance of spruce pollen during the meltwater event abruptly gave way to a dominance of pine after 8500BP. The interpretation was that spruce forests, which lingered in the area due to cold air temperature, were suddenly replaced by pine forests because of a warming that followed the meltwater event. The amplitude of the warming is estimated at 2°C. On the eastern Scotian Shelf (e.g. St. Anne's Basin), reconstructed SST were higher than today by 3-4°C before 8600 BP, suggesting that the impact of this meltwater event was not felt beyond the Gulf of St. Lawrence.

GC21A-10 0830h POSTER

Holocene Temperatures of Europe From Pollen Data

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We have investigated the large-scale patterns of climatic change during the Holocene in Europe using pollen-derived palaeoclimatic data (Davis et al., 2003). Palaeoclimate reconstructions were made at over 500 sites in Europe using a modified modern-analogue technique then assimilated and analyzed using a new spatial-temporal technique. This approach combines three-dimensional spatial griddlng with a fourth dimension represented by time, allowing data from irregular time series to be focussed' onto a regular time step. Area-averages were then calculated to give regional time series of climate change during the Holocene. The results allow Holocene changes in climate to be investigated across Europe as a whole or within and between sub-regions, and suggest major spatial and seasonal differences. Notably, evidence from southern Europe suggests widespread low latitude cooling during the mid-Holocene 'climate optimum', confirming the changes shown by Cheddadi et al. (1997). The results also provide a framework for the study of possible forcing factors. Whilst no direct relation could be found between the temperature time series and the changes in insolation, changes in the latitudinal temperature gradient follow the changes in the latitudinal insolation gradient after ca. 8 ka BP. Prior to this period, the influence of the insolation gradient was modified by the Northern Hemisphere ice cover. The study demonstrates the importance of this period within the Holocene in terms of the changing influence of climatic forcing factors. Cheddadi, R., Yu, G., Guiot, J., Harrison, S.P. And Prentice, I.C. (1997). The climate of Europe 6000 years ago. Climate Dynamics, 13, 1-9. Davis, B.A.S., Brewer, S., Guiot, J. and Stevenson., A.C. (2003). The temperature of Europe reconstructed from pollen data. Quaternary Science Reviews, 22, 1701-1716.

GC21A-11 0830h POSTER

Millennial-scale intermediate water variability in the Holocene northeast Pacific

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Using a centennially-resolved radiocarbon record from the Santa Barbara Basin, we have evaluated the Holocene record of millennial-scale intermediate water variability in the northeast Pacific. The planktonic and benthic foraminiferal radiocarbon age pairs, which are assumed to represent the coeval radiocarbon ages of the

surface mixed layer and the northeast Pacific intermediate water, respectively, indicate the presence of large changes in north Pacific intermediate water circulation throughout the Holocene. The benthic-planktonic radiocarbon age difference, B-P, is large in the earliest Holocene but drops to low values around 9500 years ago. B-P then increases through the middle Holocene, and with the exception of low values around 2000 years ago, is maximal within the past 1000 years. Along with oxygen isotope and biogenic silica data from Santa Barbara Basin, the B-P record suggests that the basin experienced increasing surface stratification and decreasing productivity from the early to the late Holocene. In addition, peaks in the B-P difference are similar to features in records of north Atlantic millennial-scale variability, suggesting a link between the north Atlantic and the intermediate north Pacific during the Holocene. We evaluate our data with respect to two contrasting models of intermediate water formation in the north Pacific (Kennett and Ingram, 1995; Mix et al., 1999) and find that, in addition to the atmospheric connection between the north Atlantic and Pacific basins, deep convection in the north Atlantic must have partially driven millennial-scale variability of intermediate water movement in the north Pacific and along the North American west coast over the last 11,000 years.

GC21A-12 0830h POSTER

A Detailed Record of Changing Surface Water Conditions From Sediments Deposited During Marine Isotope Stage 11, ODP Site 980, Northeast Atlantic Ocean

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Many recent paleoceanographic studies have focused on using high sedimentation rate deep-sea sediment sections that have produced records of abrupt climate variability operating at sub-orbital time scales. This is particularly true in the North Atlantic where proxies of changing surface water conditions from high quality sediment records have repeatedly demonstrated that millennial-scale climate change has been the rule rather than the exception over the past 500 kyr, during both glacial and interglacial intervals. Abrupt climate change during warm interglacials is an area of special interest as it may relate more directly to an understanding of recent and future climate change. With this in mind we have focused our efforts on documenting millennial-scale climate change from sediments deposited at ODP Site 980, northeast Atlantic Ocean during Marine Isotope Stage (MIS) 11. We have used unsplit, whole sample >150 micron size fractions from over 200 sediment samples to record changes in the number lithic grains per gram sediment to measure changes in the input of Ice-Rafted Debris (IRD). We then compare our new IRD record to previously generated records of changing surface water conditions during MIS11: variations in oxygen isotopic composition of the surface dwelling planktic foraminifer species N. pachyderma, right coiling and changes in the relative abundance of the polar species N. pachyderma, left coiling. Our MIS11 results are then compared to compatible records from MIS5e and the Holocene. Our detailed IRD record from around 418 kya to 382 kya reveals a remarkable lack of even trace amounts IRD input into sediments at ODP Site 980. IRD concentration abruptly drops and remains 0 to trace amounts per gram as soon as benthic delta O-18 values fall to and remain at < 3.5 per mil at the onset of MIS11. Only three very small amplitude IRD events are observed over the entire 35 kyr interval. The earliest 8 kyr of MIS11 is completely devoid of any IRD, despite the fact that the relative abundance of the polar species N. pachyderma, left coiling, after dropping from near 90% to below 10% at 418 kya, rises to as high as 30% during this early MIS11 time interval. This seems to indicate the influx of non-ice bearing colder polar waters to the region above Site 980 that don't seem to be influencing he N. pachyderma, right coiling isotope record in a simple way. The MIS11 IRD record significantly differs from our records from MIS5e and the Holocene, particularly when we focus on the earliest 12 kyr of MIS11. Both the approximately 10 kyr long MIS5e interval and the last 11 kyr of the Holocene exhibit a series of between 6 and 9 discrete small amplitude increases in IRD against a background of little or no IRD. At the same time relative abundances of N. pachyderma, left coiling are considerably less during both MIS5e and the Holocene when compared to the first 10 kyr of MIS11. The evidence presented here suggests that MIS11 surface water conditions above Site 980 were somewhat different from conditions recorded in sediments from two other warm interglacial intervals, MIS5e and the Holocene and that its use as an ancient analog to modern and future climate may be less straightforward than previously thought.

GC21A-13 0830h POSTER

Holocene Paleoceanography on the Eirik Drift

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In the summer of 2002, KN166-14 took a gravity core (GGC 21) on the Eirik Drift off the southern tip of Greenland. The core recovered 4.5 m of silty muds from a water depth of 3472 m. The 3.5 kHz sub-bottom profiler and shipboard magnetic susceptibility (MS) measurements indicate sedimentation rates are >50 cm/kyr in this location. We sampled this core for stable isotopes, %CaCO3, and grain size at 1 to 2 cm intervals. The bottom age of the core is estimated to be between 8 and 9 ka by comparing the ship board MS record with records from nearby and well-dated cores. The $\delta\ ^{18}$O curve, based on N. pachyderma (s), shows six cycles with an amplitude of $\sim 0.5^{o}/_{oo}$. These cycles appear to be the 1,500 year cycle identified by other researchers. The %CaCO3 record shows cyclicity with a similar frequency; however, the dominant feature in this record is a longer-term change from low to high %CaCO3 that occurred over the past 3 kyr. Our preliminary interpretation is that the %CaCO3 record is responding primarily to variations in drift accumulation, implicating deep-water variations. The pronounced change from 25 to 45 %over the past 3kyr represents a significant decrease in current intensity. Grain size measurements are being made to better assess the variability in the deep-water current intensity while benthic foraminiferal stable isotopes and trace metals are planned to identify source changes.

GC21A-14 0830h POSTER

Holocene Evidence for Centennial-scale Climate Variability From Records of Surface Water Changes, NE Atlantic Ocean

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Numerous detailed climate records from North Atlantic sediments reveal that Holocene climate was not as stable as previously thought; millennial-scale rapid climate oscillations that characterized the last glacial interval continued (at lower amplitude) into the Holocene (e. g., Bond et al., 1997, Oppo et al., 2003). We have previously presented evidence of such climate variability from a 3-meter Holocene section from ODP Site 980, NE Atlantic Ocean. We used closely-spaced samples to generate detailed records of variations in surface water conditions: changes in the abundance of ice-rafted debris (IRD), changes in the planktic foraminiferal assemblage, and changes in the delta O-18 of 2 planktic foraminifer species. Our previous IRD record revealed eight abrupt, small-amplitude increases in IRD occurred over the last 10 kyr against a background of little or no IRD input. Our recent efforts have focused on improving ODP 980 Holocene IRD records in two ways. First, we have cut our sampling interval in half by doubling the number of Holocene samples used to generate our records of changing surface water conditions (an increase in samples from 124 to 250 samples over the last 12 kyr), improving our sample resolution to around 50 years. Second, we have produced counts of lithic grains per gram from the unsplit whole sample >125 micron size fractions of all samples to improve our counting statistics in addition to counts from the >150 micron size fraction. We have also increased to16 the number of AMS radiocarbon dates used to generate our Holocene age model. Our improved IRD record at the >150 micron size fraction better resolves the previously identified IRD events and identifies an additional event of similar magnitude between 5.5 and 5.0 kya, not previously recorded at lower resolution. The new IRD record suggests that each event was even more abrupt and rapid than previously thought; each small amplitude IRD pulse seems to have occurred over a period of around 50 years. The IRD event at around 9.5 kya is now resolved into a series of three discrete very rapid 50-year events occurring over a period of less than 400 years. Analysis of the IRD record recorded in >125 micron size fraction does not considerably increase the amplitude of the IRD events as recorded in the larger size fraction while at the same time it increases somewhat background IRD concentrations. Comparison of our more detailed records to the other less detailed records of changing surface water conditions continues to suggest only weak correlation between SST as recorded by delta O-18 composition surface dwelling planktic foraminifers. However, comparison of our IRD record with the somewhat less detailed benthic delta C-13 record previously published (Oppo et al., 2003) indicates that 7 of the 8 IRD events occurring over the last 9 kyr are immediately followed by > 0.25 o/oo depletion in the delta C-13 content of benthic foraminifers indicating the input of cold ice-bearing surface waters over Site 980 is immediately followed by a reduction in the contribution of North Atlantic Deep Water (NADW) relative to Southern Ocean Water (SOW) at the Site.

GC21A-15 0830h POSTER

Efforts of the U.S. National Committee for the International Polar Year

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The International Polar Year (IPY) 2007-2008 is envisioned as an intense, internationally coordinated campaign of research that will initiate the dawn of a new era in polar science. IPY 2007-2008 will include research in both polar regions and involve strong links to the rest of the globe. It will be multi- and interdisciplinary in scope and truly international in participation. It will educate and excite the public, and help train the next generation of engineers, scientists, and leaders. It will include elements from a wide range of scientific disciplines, including issues related to human populations. This poster outlines recent activites of the United States National Committee to the IPY, including an update on our recent report and future planned activities.

URL: http://us-ipy.org

GC21A-16 0830h POSTER

Using Gamma Spectrometry to Determine U, Th, and K Signatures in Cap Carbonates of the Death Valley Region and Their Relation to Other Carbonates

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We collected spectral gamma data (K, U, Th) and measured sections in cap carbonates (Noonday dolomite) and cap-like carbonates (Beck Spring dolomite) of the Death Valley region in order to explore elemental changes in the post-snowball oceans. The Snowball Earth theory of Hoffman et al. (1998) proposes dramatic post-glacial chemical weathering as large concentrations of carbon were removed from the atmosphere. This would result in a large input of terrigenous material; hence, we expect that carbonates formed under these conditions would demonstrate elevated K, U, Th levels in comparison to carbonates formed under more typical conditions. However, based on our preliminary findings, cap carbonates of the Noonday dolomite and cap-like carbonates of the Beck Spring dolomite have values (0-1% for K, 0.2-6.0 ppm for U, and 0.6-6.9 ppm for Th) that fall within the published range for those measured in carbonates (presumably non-cap or cap-like carbonates). Possible explanations for this include: (a) dilution of any terrigeneous signal by the vast amount of carbonate precipitating in the oceans, or (b) any biological activity that might have an influence on chemical processes in the ocean. A preliminary comparison of our spectral gamma data measured in the Noonday dolomite with published δ^{13}C data from the same section indicate similar trends in both proxies, namely, a very gradual decrease in values through the majority of the section (Lower Noonday) followed by a more noticeable increase in values in the upper part of the section

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(Upper Noonday). Further work will be necessary to determine the significance of this possible correlation. Additionally, planned analysis of hand specimens using a high-resolution gamma spectrometer should provide more details about the composition of cap-carbonates and provide further information about the conditions under which they were formed.

GC21A-17 0830h POSTER

Is Low Latitude Sea Surface Temperature the primary regulator of atmospheric pCO2 Changes Associated with Glacial Cycles?

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Numerous hypotheses have been proposed to explain the 80 ppm reduction in atmospheric carbon dioxide concentration that distinguishes glacial periods from interglacials. A common tenet of previous studies is that the role of increased solubility of CO2 associated with cold surface waters during glacial periods plays only a minor contributing role. However, the synchronicity of global sea surface temperature changes and atmospheric CO2 changes on glacial timescales suggest that there is a causal link between the two quantities. Here we show, using a 7-box ocean carbon cycle model that a significant decrease in sea surface temperatures, together with undetectably small ocean feedback mechanisms, would have been sufficient to produce the observed drawdown of atmospheric CO2 at glacial times.

GC21A-18 0830h POSTER

Ice Age Methane Revisited: Oceans, Lightning, and the Steady Wetland Source

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The concentrations of reactive greenhouse gases in the atmosphere are a result of the interplay between sources on land and in the oceans and the atmospheric sink. Methane (CH_4) is the most important of the major, long-lived reactive trace gases, and over the past 400,000 years it has more closely paralleled the higher-frequency component of polar temperature records than any other measured gas. Analyses of ice core CH_4 concentrations and carbon isotope composition ($\delta^{13}CH_4$) have suggested that changing CH_4 emissions from wetlands drove prehistoric changes in ice-core CH_4. As a reactive trace gas, the global CH_4 budget is controlled not just by changes in source strength, but also by climate, changes in the flux of other reactive trace gases, and the nonlinear dynamics of atmospheric chemistry. To investigate the effect of long-term climate change on the atmospheric concentration of CH_4 we coupled climate, vegetation, and atmospheric chemistry models to simulate the natural emissions and atmospheric chemistry of the major reactive trace gases. Climate was simulated by a coupled AGCM/mixed-layer ocean model with simulations at 1000-year intervals from the Last Glacial Maximum (LGM, ca. 21 ka) to present. Terrestrial CH_4 and Biogenic Volatile Organic Compound (BVOC) emissions were simulated using the BIOME4-TG global vegetation model, with simple algorithms for determining wetland area based on topography and soil moisture, CH_4 emissions based on ecosystem carbon turnover in wet soils, and BVOC emissions based on vegetation type and density. We simulated atmospheric chemistry and transport with the LMDz-INCA 3D chemistry-transport model, and included a full prognostic simulation of nitrogen oxide (NO_x) emissions from lightning based on simulated convective precipitation.

Global wetland area decreased by $1x10^6$ km^2 from the LGM to the present (nearly 15%). However, CH_4 emissions - 110 Tg yr^{-1} - were nearly unchanged over this same period. During the Pleistocene-Holocene transition CH_4 emissions reached a maximum of ca. 130 Tg. LGM CH_4 emissions were ca. $2^o/_{oo}$more depleted in $\delta^{13}CH_4$ compared to present because of the increase in tropical wetland activity relative to northern wetlands. Wetland CH_4 emissions did not change drastically during the deglaciation because new wetland areas formed as ice sheets retreated, while other wetland areas were flooded by rising sea-level. Global emissions of BVOC increased significantly from the LGM to present, (350 Tg C yr^{-1} or 150%) because of increased vegetation density from warming climate and increased atmospheric CO_2 concentrations. The simulated increase in sea surface temperatures (SST) from the LGM to present led to increased convective precipitation and a 10-30% increase in NO_x emissions from lightning.

Observed rapid changes in atmospheric CH_4 concentrations over the last 21 ka cannot be completely attributed to climate change on millennial time-scales. However, the simulated changes in both the atmospheric BVOC and NO_x burdens, which compete with CH_4 as an OH sink, may have increased the lifetime of CH_4 on the order of 30% at the present compared to LGM. This strong reduction in CH_4 oxidation potential would have had long-term consequences for atmospheric CH_4 concentrations and may explain much of the ice-core CH_4 record without requiring major changes in the wetland CH_4 source.

GC21A-19 0830h POSTER

Constraints on the Southern Ocean N_2O Source Inferred From Seasonal Cycles of Atmospheric N_2O at Cape Grim, Tasmania

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The seasonal cycle of atmospheric N_2O is derived from a harmonic fit to the 10-year AGAGE observation record at Cape Grim, Tasmania (41S, 145E). After correcting for stratospheric and thermal influences, the observed atmospheric cycle is consistent with the seasonal ventilation of microbially-produced N_2O from the Southern Ocean, as predicted by an ocean biogeochemistry model coupled to an atmospheric transport model (ATM). This study is the first to reproduce observed atmospheric seasonal cycles in N_2O using specified surface sources in a forward ATM run. The comparison of AGAGE data and ATM results implies a Southern Ocean N_2O source of at least 0.9 Tg N/yr. This significant present-day contribution from the Southern Ocean suggests that the glacial oceanic N_2O source may have been reduced by the same oceanic mechanisms hypothesized to have contributed to glacial CO_2 drawdown.

GC21A-20 0830h POSTER

Lacustrine Organic Matter Elemental and Isotopic Compositions as Markers of Environmental and Paleoenvironmental Changes: Examples from Lagoa do Caco (Maranhao State, Brazil).

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Organic matter is important to the reconstruction of paleoenvironmental changes from lacustrine sediments. Organic matter and its allochtonous and autochtonous fractions provide information about the evolution of ecosystems in the lake catchment and in the sedimentation basin and about physical and chemical water column conditions. Most studies that use organic matter as a marker of paleoenvironmental changes have been limited to relative descriptions of lake evolution because they lack calibration to modern conditions. We present the results of our study of modern sedimentation of organic matter in Lagoa do Caco and their application to reconstruction of late-glacial environmental changes in northeastern Brazil. We measured C/N ratios and carbon and nitrogen isotopic compositions of organic matter in surficial sediments collected along four transverse transects and one longitudinal transect of this lake. Each transverse profile starts from a margin dominated by emergent macrophytes, crosses the central part of the lake, and finishes on the opposite margin. The elemental and isotopic results characterise the different depth-related lake environments and enable interpretation of variations in sediment bulk organic matter and its properties. C/N and del 13C values decrease and del 15N values increase from the lake edge to 4m water depth before stabilizing as algae replace macrophytes as the predominant sources of organic matter. We applied these results to reconstruct a 20-ky sediment-core history of lake level changes based on organic matter properties that reflects the evolution of regional late-glacial and Holocene climate

GC21A-21 0830h POSTER

Evaluation of Oxygen, Carbon, and Nitrogen Isotopic Paleoenvironmental Proxies in Lake Erie Sediments

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The oxygen isotopic composition of calcium carbonate that precipitates in hardwater lakes is affected by meteorologic factors whereas the inorganic and organic carbon and nitrogen isotopic compositions of lake sediments are influenced by biological productivity within the lake. All of these isotopic proxies are potentially subject to post-depositional diagenesis. We have measured the isotopic compositions at 1-cm intervals in four sediment cores that were collected in 1988, 1991, and 2003 from eastern Lake Erie to evaluate the effects of diagenesis on records of paleoenvironmental change. We have compared the isotopic contents and the mass accumulation rates of the aquatic productivity proxies organic carbon and calcium carbonate of the different cores to each other and to meteorological records beginning in 1895. Eutrophication accelerated calcite dissolution, but isotopic proxies are preserved. Calcite del 18O values that become smaller from 1980 to 1998 in the absence of evidence of a summer temperature change suggest a change in air mass trajectories. In contrast, a shift to larger del 18O values from 1905 to 1910 that is accompanied by diminished calcite precipitation and higher lake levels suggests a period of cooler summer temperatures. Increases in inorganic and organic del 13C values, del 15N values, and organic carbon accumulation starting in 1960 reflect the heightened productivity caused by anthropogenic nutrient increases to Lake Erie.

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Northern Climate Properties, Trends, and Impacts of Change: Past, Present, and Future II

Presiding: **A P Trishchenko,** Natural Resources Canada**; H Leighton,** McGill University**; K Szeto,** Meteorological Service of Canada

GC21B-01 0830h INVITED

Simulations of greenhouse-driven Arctic climate change

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As a contribution to the Arctic Climate Impact Assessment, 21st-century greenhouse-driven simulations from five global climate models were compared over a pan-Arctic domain. In addition to depending on the