(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.

GC21B CC: 524 C Tuesday 0830h

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

greenhouse forcing scenario (e.g., A2, B2), the simulated changes of temperature, precipitation and pressure are highly seasonal and spatially variable in these models. When composited over the five models, the Arctic warming is largest in the autumn and winter, as is the associated decrease of Arctic sea level pressure. The corresponding projections of changes in extremes of temperature and precipitation indicate that the Arctic's high level of natural variability reduces the statistical significance of the projected Arctic changes relative to changes in lower latitudes. The projected Arctic changes will also be presented in terms of growing season length and the northward migration of thresholds such as the 0-degree isotherm, which is ultimately related to the distribution of permafrost.

GC21B-02 0845h

Northern climate dynamics during the post-Eemian interglacial-glacial transition

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The transition of the mean state of the climate system from the Eemian interglacial into the glacial state (the MIS 5e/5d transition) is investigated using both an atmospheric general circulation model (the Canadian AGCM2) and a coupled atmosphere-ocean general circulation model (the NCAR CSMv1.4). Each model has been employed to produce both a modern control integration and an integration focused upon the summertime high latitude insolation minimum that occurred at approximately 116,000 years before present. Using the AGCM2 model, an investigation of the action of an atmospheric-cryospheric feedback mechanism involving the moisture balance of the arctic polar region will be described. This mechanism has been previously referred to in the literature as one involving a 'cryospheric moisture pump' and depends upon changes in the mid-latitude atmospheric eddy-transports of heat and moisture into the polar cap. Using the NCAR AOGCM in a complementary study, we have further investigated the response of the coupled atmosphere-ocean moisture and heat transports into northern high latitudes, both through same atmospheric baroclinic eddy transports but also due to changes in the Atlantic meridional overturning circulation (MOC) which will be fully described. A novel feature of the atmosphere-ocean simulation involves a predicted increase of the MOC during the transition into the state of high latitude continental glaciation. This feature of the coupled atmosphere-ocean simulation is consistent with inferences based upon proxy climate indicators of Thermohaline Circulation (THC) strength.

GC21B-03 0900h

Simulation of the Last and Next Glacial Inceptions With the Green McGill Paleoclimate Model.

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A fundamental question in Quaternary science is to determine when the present interglacial will end and when the next ice age might occur. Whereas scientists predicted an imminent glaciation in the 1970s, it seems today that the present interglacial may last longer, due to an exceptional configuration of the future variations of the summer solar insolation at northern high latitudes. The McGill Paleoclimate Model, with its recently added vegetation component, has first been run to simulate the climate of the past (from 122 kyr to 80 kyr BP), i.e. the last glacial inception. Results show a glacial inception around 117 kyr BP followed by a rapid building of ice sheets over North America, and a slower increase of ice volume over Eurasia. The model has then been run to simulate the short-term future with various increasing atmospheric CO2 concentrations, to find the possible responses to global warming. The results are quite similar to those obtained by GCMs, and lie in the IPCC range of results. Finally, the model has been run to simulate the climate of the next 100 kyr, i.e. the next glacial inception, with different scenarios for the atmospheric CO2 concentration, both constant and variable. We shall present the thresholds in carbon dioxide concentration that will determine the occurrence or absence of glacial inception in 50 kyr.

URL: http://www.esmg.mcgill.ca

GC21B-04 0915h

Multivariate Analysis of Long Term Variability in Icelandic Hydrological Series and its Relation to the Atmospheric Circulation in the North Atlantic

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Observed long-term variability in Icelandic time series of river flow is quite regular and significant. Similarly, aggregated long-term observations of glacial termini show significant changes since their initiation some 70 years ago. The relationship of these changes to variations in time series of climatic and oceanographic variables is quite important, since it can give indications of the possible relationship between hydrological time series and climate variability such as the Northern Atlantic pressure Oscillation (NAO). It can also give indications of the possible effects of anthropogenic climate changes due to increased concentration of greenhouse gases in the atmosphere. The variability of the atmospheric circulation in the North Atlantic has great effects on the precipitation and runoff in Iceland and in fact on the hydrology of the Nordic countries and the contries of western Europe. The island is situated in the middle of the North Atlantic Ocean in the path of the low-pressure frontal systems that transport moisture and thermal energy from the South to the North. A multivariate statistical analysis is performed on discharge data for several rivers in Iceland. The variability in the characteristics of the rivers is large since their watersheds are in various parts of the country, where glaciers and groundwater play a large role in the hydrology of some of the watersheds. The modes of variability are identified by a principal component analysis and the physical explanation of the modes is searched for by canonical correlation with data on precipitation, temperature, sea level pressure and other climatic and oceanographic variables. This study should give information on what processes relate the variability of the atmospheric circulation to the variability of the Icelandic rivers. It will thereby reveal the options of predicting the hydrological conditions in Iceland based on indices and information from the general prevalent circulation patterns. An extension of these studies is planned within a joint Nordic project on Climate and Energy that will include time series from the other Nordic countries.

GC21B-05 0930h

Climate Change in Northwestern North America Over the Last Three Centuries

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The relatively short length of most instrumental climate datasets restricts the study of variability that exists in the climate system. This is particularly true regarding the atmosphere where high quality spatially dense data exists only since the late 1940s. With this data, the Pacific North America pattern (PNA) has been identified as one of the dominant modes of variability in the atmosphere. Over this period the PNA has been related to the Pacific Decadal Oscillation (PDO), a mode of climate variability that has been shown to influence marine productivity in the North Pacific as well as modulating the impact of the El Niño-Southern Oscillation in North America. Here we present an updated 301-year ice core record from Mount Logan in northwestern North America that shows a statistically significant and accelerating positive trend in snow accumulation from the middle of the 19th century. A manifestation of this trend has been a warming over northwestern North America that, for much of the 20th century, has been associated with secular changes in the PNA and PDO.

GC21B-06 0945h

Impacts of Climate and UV Change on Arctic Freshwater Ecosystems

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An overview is provided of the key findings of the Arctic Climate Impact Assessment (ACIA), which is an international project of the Arctic Council and the International Arctic Science Committee (IASC), to evaluate and synthesize knowledge on climate variability, climate change, and increased ultraviolet radiation and their consequences. Predicted changes in climate and UV in the Arctic are expected to have far-reaching impacts on the hydrology and ecology of freshwater ecosystems. Key effects include changes in the distribution, abundance and ecology of aquatic species in various trophic levels, dramatic alterations in the physical environment that makes up their habitat, changes to the chemical properties of that environment, and alterations to the processes that act on and within freshwater ecosystems. Interactions of climatic variables, such as temperature and precipitation, with freshwater ecosystems are highly complex and hence can be propagated through ecosystems in ways that are often difficult to predict. This is partly because of our still relatively poor understanding of the structure and function of arctic freshwater systems and their basic interrelationships with climate and other environmental variables, as well as by a paucity of long-term freshwater monitoring sites and integrated hydro-ecological research programs in the Arctic. Predictions of hydro-ecological impacts are further complicated by synergistic and cumulative effects.

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GC22A CC: 524 C Tuesday 1030h

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

Presiding: **A J Weaver,** University of Victoria**; L Trichtchenko,** Geomagnetic Laboratory, Natural Resources Canada

GC22A-01 1030h INVITED

Reducing Canada's vulnerability to climate change: a new research program of Natural Resources Canada

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There is broad scientific consensus that anthropogenically enhanced climate change is underway, that its impacts will be particularly pronounced in northern areas and that, regardless of the effectiveness of the proposed mitigation measures, future climate changes will occur due to the inertia of the climate system. The Earth Sciences Sector of Natural Resources Canada initiated a new program aimed at providing knowledge that will help Canadians to cope with adverse consequences of, and to benefit where possible, from the impacts of climate change on Canada's landmass. The fundamental goals are to improve the scientific understanding of the impacts of past, present, and future climate variability and change on Canada's landmass and the coastal zone, of associated costs, and of the implications for adaptation options; and to ensure this information is used to better prepare Canadians for the future. The program utilizes geoscience and geomatics techniques and expertise to observe, analyse or model the sensitivity of Canada's cryosphere (glaciers and permafrost), ecosystems (carbon, water, energy cycles) and coasts (coastal dynamics and sea level rise) to climate variability and change. Spatially, program activities address questions at national, regional or local/municipal levels. The time domain of interest spans the last 18000 years and the next 20- 100 years. The key scientific questions are formulated within the following streams: monitoring and analysis; GHG sinks and sources; processes; scenarios; and costs/ adaptation options. Explicit linkages with stakeholders and users of scientific information have been established to achieve effectiveness of the research results.