strong correlation between total S and total C is observed, suggesting that Sulfide formation is limited by the amount of labile organic matter present. The data from the two cores show strong evidence for eutrophication over the last 200 years, with a strong increase in the N supply.

GC43A-03 1330h POSTER

Development of Micropaleontological and Geochemical Indicators of Eutrophication in the St. Lawrence Estuary

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Recent measurements show that an estimated 1300 km2 of the bottom of the St. Lawrence Estuary is now bathed by hypoxic waters (i.e., waters containing less than 62.5 μM or 2 mg/l of dissolved oxygen). Eutrophication is one of the possible causes of hypoxia. An increased flux of nutrients from the watershed would lead to an increase surface productivity and organic carbon flux to the bottom waters. The microbially-mediated remineralization of this organic carbon will result in the progressive depletion of dissolved oxygen in the bottom waters. We have analysed sediment cores collected in the lower St. Lawrence Estuary in order to investigate temporal changes in productivity since the pre-colonial period and to identify evidence of eutrophication. The chronology of the cores is based on 210Pb measurements. The upper part of the box cores (upper 20 cm) is characterized by a very high sedimentation rate of 0.74 cm/yr. In the lower part of the core, sedimentation rates decreased to 0.28 cm/yr. Organic carbon content and its Δ13C signature were used to reconstruct the fluxes, provenance and nature of the organic matter. The concentration and assemblages of dinoflagellates cysts served to estimate the variation in planktonic productivity whereas the abundance of benthic foraminifera and their organic linings were used to estimate variations in benthic production. The data clearly show an increase in the Δ13C of preserved organic matter since the 70's, which we interpret as a shift toward enhanced contribution from a marine source of organic carbon. This shift corresponds to a significant increase in dinocyst concentration, possibly reflecting an increase in primary production of the surface waters. Moreover, there is an increase in the concentration of organic linings of benthic foraminifera suggesting a concomitant increase of benthic production.

GC43A-04 1330h POSTER

Radiocarbon Studies of Long Island Sound Sediments

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We analyzed organic material and carbonate shells from core samples in Long Island Sound (LIS) for d13C and radiocarbon to investigate changes in reservoir ages due to anthropogenic changes in the carbon cycle. In addition, we dated shells from several LIS cores to establish chronologies for the development of the Sound from the marine incursion to modern day sedimentation. Reservoir ages in estuaries vary spatially and temporally due to the added old dissolved carbon from freshwater as well as changes in marine and freshwater fluxes and mixing processes. Sources of reservoir changes can be traced with the combined use of d13C and 14C in shells. This study used the time-dependent marine reservoir curve (Stuiver and Brazunias, 1993) to calculate local LIS reservoirs. Reservoir ages in Long Island Sound seem to increase steadily from 1000 AD to 1500 AD at a rate of .2 reservoir years/14C years (dR decreases from -137 to -353 14C years). Reservoirs after 1750 AD range from -464 to 185 14C years, showing no spatial or temporal trends. The d13C of carbonates also vary more during this time period. The input of dissolved terrestrial old carbon' via rivers was probably higher during the Medieval Warm Period. After colonization, increased anthropogenic carbon input from sewage and watershed export as well as oxidation of the enhanced primary productivity contributed both young and older carbon to the Sound causing extremely variable and localized reservoirs. Our 14C measurements on marine mollusks from before 8000 BP show a steady sedimentation rate of 1.6 mm/year in Eastern LIS. These dates suggest that the marine incursion occurred at about 11,000 BP. Our 14C measurements on terrestrial organic debris from the LIS cores show significantly older dates than those from carbonates in the same samples, suggesting that most terrestrial particulate organic matter is several 1000 years old before it enters the Sound. For the early history, the organic carbon was possibly first stored in glacial lake deposits before it was transported to LIS. If so, the chronology of the marine incursion into LIS, which is largely based on radiocarbon dates of organic matter, may have to be revised.

GC43A-05 1330h POSTER

Benthic Foraminifera in the Changing Ecosystem of Long Island Sound

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Long Island Sound (LIS) is an estuary in a heavily urbanized region; Long Island lies to its South, New York City (NYC) to its West and Connecticut to its North. The Connecticut River contributes >70% of the fresh water influx. LIS has a narrow opening to the West (into East River), but exchange with the ocean occurs dominantly at its eastern end, resulting in an east-west gradient in salinity. An east-west gradient is also present in indicators of anthropogenic contamination in the surface sediments (e.g., trace metals) because western LIS is close to the major source of anthropogenic input (NYC). In addition, bottom currents focus fine-grained, contaminant-loaded sediments there. Since the early 1970's western LIS and parts of central LIS have suffered summer hypoxia, probably as a result of increased algal growth caused by anthropogenic nitrogen input. Benthic foraminifera are eukaryote heterotrophic organisms with a calcareous or agglutinated test. We investigated changes in their populations over time in about 2m-long gravity cores in westernmost (WLIS75GGC1; 73^o 40'W, 40^o 52'N, 19m waterdepth) and coastal central LIS (B1GGC1; 73^o 4'W, 41^o 10'N, 8m water depth), to document environmental changes over the last millennium, including the time of European settlement and the industrial revolution and population increase. An age model was derived from metal pollution records and ^{14}C dating. Before European settlement, the low-diversity benthic faunas in core B1GGC1, at a depth within the zone of light penetration, were dominated by *Elphidium excavatum*, a species feeding on living diatoms. In western LIS (below the zone of light penetration) this species was less abundant and *Elphidium incertum* and *Buccella frigida* were common. In both cores, the absolute abundance of benthic foraminifera and the relative abundance of *Elphidium excavatum* increased in the early 1800's, coinciding with a time of rapid increase in human population around LIS and slightly before an increase in trace metal concentration. The ecological changes may have been caused by increased productivity of diatoms resulting from beginning anthropogenic eutrophication. From the middle 1960's on, absolute foraminiferal abundance decreased and *Ammonia beccarii*, formerly absent or rare, became common to dominant in WLIS75GGC1; in B1GGC1 a similar but less severe change started in the 1970's. The increase in relative abundance of *A. beccarii* could have been caused by hypoxia (possibly in conjunction with rising bottom water temperatures), but both *Ammonia* and *Elphidium* species survive hypoxia in the laboratory. We suggest that high N/Si resulting from strong eutrophication might favor primary producers other than diatoms (e.g., dinoflagellates, cyanobacteria), making *E. excavatum* less competitive. The LIS coastal ecosystem thus changed significantly with the enhanced nutrient input associated with human population growth in the middle 1800's, and again with more severe eutrophication over the last few decades.

URL: http://ethomas.web.wesleyan.edu/lisweb

GC43B CC: 524 C Thursday 1330h

Continental Energy Balance, Land-Surface Processes, and Surface Temperature II

Presiding: **R N Harris,** University of Utah**; H Beltrami,** St. Francis Xavier University

GC43B-01 1330h

Solar Radiation and Climate Change in the Great Plains

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The global average air surface temperature has increased about 0.6°C over the 20th century (Houghton et al. 2001). This warming has resulted in a 10% decrease in the extent of snow cover observed from satellite, and about two weeks reduction in the annual duration of lake and river ice cover in the mid- and high latitudes of the Northern Hemisphere from ground-based observations (Houghton et al. 2001). In the Great Plains, we found ground-surface warming increases systematically with latitude from 0.4°C per century at 41.1°N to 2.0°C per century at 49.4°N (Gosnold et al. 1997). This project expands our study to investigate coherence between ground-surface temperatures, solar radiation, and all other relevant meteorological data. We have collected more than 20 years of surface meteorological data, such as soil temperatures, surface air temperatures (SAT), precipitation, and downward solar radiation, from the High Plains Regional Climate Center (HPRCC) in Lincoln, Nebraska since 1981. The daily mean values of meteorological data within the states of Kansas, Nebraska, South Dakota, and North Dakota have been binned and averaged to 0.5-degree latitude intervals to study temporal and latitudinal variations of soil temperatures, SAT, and solar radiation as well as their coherences. This area covers the latitudes of 37°N to 49°N, and the longitudes of 95°W to 104°W. Through this study, we are attempting to answer the following questions: (1) How does this warming trend relate to solar radiation? (2) How does this warming trend relate to the satellite-measured 10% decrease in the extent of snow cover since late 1960's and the ground-based observed 2-week reduction in the annual duration of lake and river ice over the Great Plains? (3) What is the coherence between the SAT and soil temperature during the study period? (4) What are the causes of this observed warming trend?

GC43B-02 1345h INVITED

Landcover change and Climate

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Recent modeling studies have shown that human changes in landcover can affect surface climate on both regional and global scales. Changes in landcover are relayed to the atmosphere as changes in moisture and energy balances and through perturbations to biogeochemical cycles. We will present examples of these effects on a variety of time and spatial scales. Landcover change in the tropics is also associated with simulated changes in large scale circulations such as the Hadley and Walker cells, and monsoon circulations resulting in climatic effects that are non-localized and global in extent. Recently observEd changes in natural circulation regimes such as the NAO/AO and ENSO are responsible for a large portion of the observed global surface warming in recent decades. Because landcover changes appear to affect these circulations, it is possible that the effect of landcover changes may explain some part of the discrepancy between climate change simulations and observations.

GC43B-03 1415h

Why are warming estimates based on borehole temperature records greater than multiproxy reconstructions?

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Reconstructions of Northern Hemisphere surface temperature change based on borehole temperature-depth profiles indicates $0.7\pm0.1^{\circ}$ C of ground warming between pre-industrial time and the 1961-1990 mean surface air temperature (SAT). SAT data show another 0.4° C of most recent warming; thus the total surface warming may be as much as 1.1° C [*Harris and Chapman, GRL,* 2001]. In contrast most multiproxy records suggest significantly less warming, about 0.7° C, over the same time period. The geothermal results imply that Earth has greater sensitivity to climatic forcings than implied by multiproxy reconstructions. We first verify that the mid latitude ($30^{\circ} - 60^{\circ}$ N) transient temperature profile, constructed from the global database of temperature profiles, shares much information in common with the Northern Hemisphere SAT record at site collocated with boreholes. The combination of an initial temperature (the primary free parameter) with the last 140 years of SAT data yields a synthetic temperature profile that is an excellent fit to observations, accounting for 99% of the observed variance. This strong correlation suggests that over large areas and long time-scales ground and air temperatures are responding to similar forcings. The discrepancy between warming estimates from temperature profiles and multiproxy warming is troubling. Attempts to reconcile these results by investigating potential biases in temperature profiles, including snow cover, and topography have been unsuccessful. We suggest that the discrepancy in warming estimates may be due to the different frequency contents of the two records. Temperature profiles contain longer period information than multiproxy records. We highlight the proxy reconstruction of *Espers et al.* [*Science,* 2002] which provides good agreement with borehole temperature reconstructions and retains longer period information than other proxy reconstructions.

GC43B-04 1430h

An evaluation of the effects of deforestation on subsurface temperatures

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Changes in land surface conditions such as deforestation or forest fires modify the energy balance at the ground surface. Such energy imbalances appear as subsurface transient thermal signals superimposed on the climatic signal and the steady state geothermal field. Borehole temperature data located in areas affected by deforestation need to be corrected for the non-climatic energy perturbations in order to be used in climatological studies. Here we show a first order approach to correct borehole temperature data for the effects of deforestation. We simulate the ground surface temperature (GST) variation after deforestation using a combined gamma-logistic function, describing the forest floor organic matter decay and recovery after a clear-cut. The forest floor organic matter acts as an insulating layer, and its variation, which is driven mostly by the microbial activity and the quantity and quality of the litter inputs, affects the energy balance at the air-ground interface. After deforestation, the thickness of the organic matter layer decreases allowing more energy to be absorbed into the subsurface. The ground surface temperature increases monotonically to account for the soil temperature difference between the forest and open areas. However, as the secondary forest approaches the equilibrium state, the GST will decrease to near its pre-harvest value. Results of this study suggest that the proposed correction method can be applied if the time and the magnitude of deforestation are known. We show that the effects of deforestation on the subsurface temperatures, though important, are much smaller than previously thought. These results may also allow land surface models to use geothermal data in regions of known land disruption, in order to optimize long-term land-surface energy exchange parameterizations.

GC43B-05 1445h

Atmosphere-land surface coupling in the high northern latitude tundra-taiga transition zone

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The position of northern hemisphere polar frontal zone in summer is highly correlated with the northern limits of the boreal forest. A great deal of discussion concerns the idea as to whether the tundra-taiga limit plays a passive or an active role in determining the preferred position of this polar climate transition zone. Of particular interest in these discussions is the role played by surface albedo in determining the differential heating of the atmosphere along this transition zone during the spring and summer seasons. In order to realistically simulate the surface energy balance involved in atmosphere/land coupling, a new surface albedo module is being developed for the Lund-Potsdam-Jena dynamic global vegetation model (LPJ-DGMV). The physics of this module is based upon a novel semi-empirically derived light scattering theory. A preliminary discussion of this line of research will be presented along with a discussion of implications for past vegetation distributions in the simulations of glacial inception climate that have been performed using the NCAR climate system model version 1.4 (CSM 1.4) and the LPJ-DGVM model. Simulations of both the modern climate and the climate during the most recent period of glacial inception (116 000 years ago) will be presented.

GC44A CC: 524 C Thursday 1530h

Continental Energy Balance, Land-Surface Processes, and Surface Temperature III

Presiding: **R N Harris,** University of Utah**; H Beltrami,** St. Francis Xavier University

GC44A-01 1530h

Evaluating the Common Procedure to Determine the Energy Balance at the Earth's Surface from Space

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The common procedure to determine the energy balance and, hence, the brightness temperature at the earth's surface on the basis of satellite data will be evaluated by discussing the inherent procedural and stochastic errors. The evaluation will be performed for aerodynamically smooth surfaces like the surfaces of natural water systems and snow packs as well as aerodynamically rough surfaces covered by low and tall vegetation elements.

URL: http://www.gi.alaska.edu/~kramm/S04

GC44A-02 1545h

Assessing seasonal and annual coupling relationships between air and subsurface temperatures: What can these relationships tell us about ground surface temperature reconstructions?

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Ground surface temperature (GST) reconstructions determined from temperature profiles measured in terrestrial boreholes, when averaged over the northern hemisphere, estimate a surface warming of approximately 1 K during the interval AD 1500-2000. Other traditional proxy-based estimates suggest less warming during the same interval. Seasonal filters' in both borehole- and proxy-based reconstructions have been suggested as one possible explanation of these differences. Here we quantify seasonal decoupling between GST and surface air temperature (SAT) signals and assess the potential for this decoupling to cause seasonal biases in borehole-based temperature reconstructions. SAT and subsurface temperature time series have been measured and analyzed at Fargo, North Dakota; Prague, Czech Republic; and Cape Hatteras National Seashore, North Carolina. Extrapolation of subsurface annual signals to the ground surface yield amplitude and phase estimates of annual GST signals at these sites. When compared to the annual SAT signals, annual GST signals are modestly attenuated and negligibly phase shifted relative to SAT; the amplitude attenuation and phase shift ranges are approximately 7.6-22.5% and 4.6-8.4 days, respectively. Of the three analyzed sites, amplitude attenuation was greatest at Fargo and least at Cape Hatteras. At Fargo, the most extreme winter site in our study, attenuation occurred predominantly in the winter season when snow cover and/or subsurface freezing inhibit cooling of the subsurface. At Prague, a site with approximately the same amount of annual rain-equivalent precipitation as Fargo but milder winters, amplitude attenuation was relatively balanced between both winter and summer seasons. At Cape Hatteras, where winter effects are largely absent, attenuation was distributed primarily in the summer season due to evapotranspiration effects. Our results illustrate that decoupling between annual GST and SAT signals is driven by processes occurring in both summer and winter seasons, suggesting that seasonal effects throughout the year must be considered to accurately assess annual relationships between SAT and GST, and the evolution of annual relationships over much longer timescales.

GC44A-03 1600h

Ground warming patterns in the northern hemisphere during the last five centuries

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Changes in the Earth's surface energy balance recorded underground have been used to reconstruct the temperature of the ground surface for the last 500 years in the northern hemisphere. We reconstructed ground surface temperature histories (GSTHs) from temperature versus depth profiles measured in 558 sites distributed between $30^{\circ}$and 60°N in the northern hemisphere using an inversion algorithm based on singular value decomposition. We show that that the ground has warmed about 1.0 K in the last 500 years. Spatial analysis reveals that spatial variability is important. Local short term oscillations are superposed to the general warming trend. Recent cooling is observed in Canada and Central Europe. The largest warming occurred during the last 50 years over the whole hemisphere and is more intense over the North American continent and South-Eastern Asia. To facilitate comparisons with previous northern hemisphere studies we computed an hemispheric average using several spatial averaging methods including a "cosine" projection algorithm. Although ground surface and air temperatures comparison is rather problematic, the weighted average northern hemisphere GSTH shows some consistency with multiproxy reconstructions for the last two centuries.

GC44A-04 1615h

GCM-Scale Blending Heights From the BOREAS Observations

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GCM modeling studies which examine the interaction between the land surface and the atmosphere above heterogeneous terrain, have shown that the air characteristics above different surface patches become