A comparison of estimated current and future climate scenario exhibited a decrease in the peak and volume of flows, particularly for the dominant Peace River. Also the warmer temperatures of future climate scenarios and lower flows in the Peace and Athabasca Rivers influences the timing and growth of ice jams, the major mechanism by which the PAD is hydrologically regenerated. This effect is compounded by the reduction of flow depth and volume. The sensitivity of the PAD to climate change was assessed by utilizing the hydrographs generated by the hydrologic model forced with climate change scenarios temperature and precipitation. Using the hydrodynamic model, it is estimated that lake levels will be reduced considerably (in the order of 30 - 60 cm) under climate change. Increased temperatures, which accelerate spring melt and reduces its impact, is key. Water fluctuations in the major rivers feeding the PAD are even more significant with up to 2 m reductions in water levels estimated. Flow reversals occur less frequently under a changed climate.

GC23A CC: 220 C-E Tuesday 1330h

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

Presiding: **H Leighton,** McGill University**; K Szeto,** Meteorological Service of Canada

GC23A-01 1330h POSTER

Contributions of Plant Respiration to Ecosystem Respiration at Mer Bleue Bog, Ottawa, Ontario, Canada

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The goal of this research was to quantify the relative contribution of plants to ecosystem respiration at Mer Bleue Bog, Ottawa, Ontario in order to better understand the variations in ecosystem respiration recorded by an eddy covariance tower at the site. Mer Bleue Bog is an ombrotrophic peatland dominated by dwarf evergreen and deciduous shrubs with a continuous Sphagnum moss ground cover. As part of the Fluxnet Canada program, the bog is a long-term research site for carbon cycling involving a host of collaborators from a variety of fields and institutions. We attempted to exclude plant respiration by shading the plants and reducing PAR to less then 40 umol photons/m2/sec during the growing season assuming that by preventing photosynthesis, plant respiration would also be eliminated. Reductions in plant respiration were measured by changes in net ecosystem exchange of CO2 using a LiCor 6200 photosynthesis system and a closed chamber system. Soil respiration was not significantly reduced in the shaded plots compared with the unshaded plots. The only significant difference between shaded and unshaded plots was the slope of the linear regression of soil respiration against temperature. Shaded plots maintained their slope throughout the summer while unshaded plots showed a decrease in the slope, indicating that soil respiration became less sensitive to temperature over that time. It is possible that shading may have benefited the plants by conserving soil moisture during the drought period spanning July and August when the water table dropped 30 cm.

GC23A-02 1330h POSTER

Evaluation of Global and National LAI Estimates over Canada

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Leaf area index is a fundamental land surface parameter. Moderate (1km) resolution sensors currently offer sufficient repeat frequency to provide large area estimates of LAI within the growing season. Recently, a number of LAI products have been produced and distributed for use in ecosystem and climate models. We describe an approach to validet these products using a sampling of consistent in-situ LAI measurements scaled up with Landsat data. This reference data set is used to quantify both the contribution of scaling versus retrieval algorithm uncertainties in the MODIS, CCRS , ESA and IGBP LAI products. An additional intensively sampled site near Ottawa, Canada and within the VALERI international validation network is used to compare our reference approach to other international reference standards. The LAI uncertainties are propoagated into a land surface process model to quantify expected downstream uncertainties in modelled fluxes.

GC23A-03 1330h POSTER

Quantitative Reconstruction of Holocene Climates of Canadian Arctic and Greenland from pollen assemblages

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Ice cores have provided key records of the late-Quaternary climates of the North American Arctic. However, these are spatially restricted and are available only in the glaciated eastern Arctic and Greenland. Ten pollen diagrams are available from Banks, Prince of Wales, Somerset, Ellesmere and Baffin Island describe the changes in the postglacial vegetation. These pollen assemblages, along with other proxy-climate data, have been interpreted as indicating a relatively warm early Holocene with a cooling in the past several 1000 years. However, quantitative reconstructions of the magnitude of temperature change have been hampered by lack of a sufficiently extensive modern calibration dataset. A new modern pollen dataset has recently been prepared, permitting the quantitative reconstructions of summer conditions across the Arctic. We use the modern pollen dataset, along with high-resolution estimates of July temperatures to estimate the magnitude of the Holocene climate changes across the Arctic and compare these results to the ice core records.

URL: http://www.uottawa.ca/academic/arts/geographie/lpcweb/

GC23A-04 1330h POSTER

Aerosol Radiative Forcing over Western Canada from CERES and MODIS Observations

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Aerosol radiative forcing can have an important effect on the climate system. The CERES and MODIS instruments on the Terra and Aqua satellites provide a very good opportunity to investigate aerosol radiative forcing. In this study, solar fluxes at the top of the atmosphere (TOA) and cloud amount information are taken from the CERES ES8 dataset, and aerosol optical depths are retrieved from the MODIS MOD04_L2 dataset over western Canada within the longitude range $210^o - 280^o$ and latitude range $45^o - 75^o$, covering the Mackenzie River basin. The data are interpolated temporally and gridded spatially onto a 0.2^o latitude x 0.2^o longitude grid for each overpass. Results show that during the two months of July and August 2001 the retrieved aerosol optical depth from MODIS has a large spatial variation. Within the Mackenzie River basin, the mean optical depth over these two months varied spatially from less than 0.1 to more than 0.3. For the boreal forest region on the southern edge of the Mackenzie River basin, the mean aerosol optical depth was typically about 0.3 but for many locations it was greater than 0.5. Aerosol radiative forcing at the TOA is derived from coincident and co-located CERES and MODIS overpasses centered at around 18.56 UTC (local time around 11.56AM) in July and August 2001. The aerosol forcing at the surface is calculated from the parameterization of Li et al. (1993) and an aerosol correction term to the parameterization proposed by Masuda et al. (1995). The noon-time basin-averages of aerosol radiative forcing at the TOA and at the surface for these two months are $11 Wm^{-2}$ and $-30 Wm^{-2}$ respectively, and the average of the aerosol optical depth is 0.15 over the study region.

GC23A-05 1330h POSTER

Long-term variability and trends in the shortwave albedo of North America Rocky Mountains detected from coarse resolution satellite data as indicator of changing climate

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Shortwave (SW) albedo of mountainous regions serves as indicator of climate change. SW albedo for relatively low altitudes may reduce due to shrinking of snow/ice pack in the warming climate. For high elevations, albedo may change due to changes in amount of precipitation (snow). We analysed coarse resolution satellite data available from AVHRR and International Cloud Climatology Project to detect variations and trends of shortwave albedo over Canadian Rocky Mountains from 1983 to 2000. Despite quite substantial interannual variability, there exist well-defined negative trends in SW albedo for mid summer (July) conditions. For 11 selected regions, that cover areas from 45N to 65N, the average observed trends varied from -3.3 to -8.6 percent for decade. Average trend is -6.1 percent for decade. Similar negative trends are detected from satellite radiation budget missions, such as ERBE and CERES.

GC23A-06 1330h POSTER

How consistent is cloudiness over Canada from satellite observations and modeling data?

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Being one of the major modulators of radiation budget and hydrological cycle, clouds are still significant challenge for modeling and satellite retrievals. For example, our analysis shows that for Western Canada the systematic difference in total cloud amounts between NCAR/NCEP Reanalysis-2 and ISCCP reaches 20-30 per cent. Especially difficult are satellite retrievals for Northern climate regions over snow-covered surface and during night-time. To understand better these differences and their influence on earth radiation budget in Northern latitudes, we are attempting to undertake the re-analysis of satellite AVHRR data over Canada using improved data processing and cloud detection algorithms. Details of cloud detection algorithm for day-time and night-time conditions over snow-free and snow-covered surfaces are discussed. Selected results of satellite retrievals for typical summer and winter conditions over Canada are compared to previous analyses, such as ISCCP and Pathfinder projects. Consistency between our cloud retrievals using AVHRR data and those available from MODIS will be also considered.

GC23A-07 1330h POSTER

Simulation of Snow Dynamics in Response to Climate Variability

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Snow dynamics not only affects the energy dissipation in northern ecosystems during non-growing season, but also affects plant growth through its impact on the soil water conditions of early growing season. To better simulate the snow and soil dynamics, a multiple-layer

snow and soil interaction module has been recently developed within the Ecological Assimilation of Land and Climate Observations (EALCO) model. Up to 6 snow layers and 6 soil layers with flexible depth are currently represented in the module. Soil or snow skin temperature is obtained by numerically solving the surface energy balance equation. Energy dissipation to latent, sensible and soil/snow surface heat fluxes are thus calculated. Snow density is simulated in consideration of both compaction and destructive metamorphism, which depends on snow age, temperature and the residing weight above. The snow surface albedo, thermal and water properties and change of snow depth are updated in each time step and snow layers are re-calculated accordingly. The temperatures of snow and soil layers are implicitly solved in a tridiagonal linear system for thermal conduction equations. Freezing and thawing are computed according to the solved layer temperature and the existing water phase in the layer. Water movement between snow layers is computed according to the liquid water content and water holding capacity. Soil Water movement is simulated using Richard's equation and Darcy's law. The soil water content of each layer is thus implicitly solved as for temperatures. The model runs in half-hourly time step and main outputs include snow depth, snow water equivalent, and the temperature and water profiles for both snow and soil. In this study, the model was tested using data collected from several Canadian sites in the prairie and boreal forest region. The observed snow depth and temperature were compared with the corresponding model outputs. Sensitivities of snow cover change and soil thermal and moisture regime to climate variability were investigated through model simulations.

GC23A-08 1330h POSTER

Coastal Impacts of Climate Change in the Canadian Beaufort Sea

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Retreat of the Beaufort Sea coast is driven by relative sea-level (RSL) rise coupled with wave and storm surge impacts which can cause up to several metres retreat of partially thawed, unconsolidated cliffs during a single storm. Storms are only effective as erosional agents during the June to October open water season when waves are not completely damped by nearshore sea ice. The signatures of climate change in the region are anticipated to include accelerated sea-level rise, decreased sea ice extent, and increased temperatures. Mean storm intensities and annual frequencies are anticipated to remain constant, but storms will occur over a longer open water season, with higher water levels associated with wave action higher on the shoreface and flooding further inland. Cliffs may also be more susceptible to erosion by virtue of warming air temperatures and increased active layer thickness. Analyses of historical records of winds, water levels, sea ice and air temperatures from the region indicate that open water season stormy periods occurred in the early 1960s and the mid-1980s. Sea ice extent is variable in the open water season with approximately five year periodicity between heavy and light years and an apparent trend towards a longer open water season reflected in a similar apparent warming trend in air temperature. At Tuktoyaktuk, northwesterly open water season wind events are not well correlated with high water level events as water levels are influenced by additional factors other than local winds. In multiple regression, peak storm wind speeds and directions were found to explain 66% of variability in peak storm water levels though open water extent did not significantly contribute. Calculations of return periods using the Generalised Pareto Distribution and Peaks-Over-Threshold method indicate a 25 year return period for wind speeds of 96 km/h and water levels of 2.3 m chart datum. Return periods were also calculated for 2050 and 2100 assuming storms occurring over a lengthening open water season with no change in frequency or intensity, and water levels elevated according to predicted RSL rise. The 25 year wind speed is expected to increase only slightly by 2100 though the 25 year extreme water level is expected to increase to 3.2 m. CGCM results indicate increasing temperatures and the Beaufort Sea ice climate becoming similar to the present day Gulf of St. Lawrence. This scenario of climate change will have strong impacts on shorelines of the Beaufort Sea, bringing more severe flooding and accelerated coastal change.

GC23A-09 1330h POSTER

How Sensitive Were Permafrost Dynamics in Western Canadian Peatlands to the Little Ice Age and 1500-Year Holocene Wet-Dry Climate Cycles?

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Permafrost thaw and resultant change in carbon sink-source relationships of peatlands at the southern limit of permafrost zone have become a major concern and focus in global change research. Understanding the local ecological and regional climate controls of peatland permafrost dynamics is essential to assessing and projecting possible future changes. In boreal western Canada, the accepted regional model of Holocene permafrost dynamics describes current wide-spread thaw as caused by climate warming at the end of the Little Ice Age (LIA). However, little detailed paleoecological and chronology data are available to evaluate this assumption. Here we present a new peat-core record from a peatland complex that contains localized permafrost mounds and thawed internal lawns at the southern limit of permafrost zone in Saskatchewan, Canada. The core was taken from a treeless internal lawn in the Patuanak Peatland. The 325-cm long core that penetrated to basal mineral soil was analyzed at 1-cm sampling resolution for organic matter content and bulk density. The 9670-yr chronology was controlled by 5 AMS radiocarbon dates. The top date of 380 ± 30 ^{14}C BP (calibrated 470 cal BP) was measured on *Picea mariana* needles at 78 cm - the latest occurrence of needles derived from trees that drowned following permafrost mound collapse. Macrofossil results of the top 80 cm indicate a sequence of fast species succession from dominance by Cyperaceae, *Sphagnum riparium, S. angustifolium*, and *S. magellanicum* to *S. fuscum*. The apparent carbon accumulation rates are invariable at 43 gC m^{-2} yr^{-1} from 9 to 1.3 cal ka, but decrease to 22.5 gC m^{-2} yr^{-1} at 1.3-0.47 ka. The last 470 years have the highest accumulation rate of 93 gC m^{-2} yr^{-1}. The date of 470 cal BP is the first direct radiocarbon date of southern permafrost thaw, which is much older than the post-LIA age often assumed and is closer in age to the beginning of the LIA period. The fact that this core is similar in thaw depth to 6 other internal lawn cores from Patuanak indicates that the age is representative of main thaw initiation throughout the peatland. This suggests that either local factors, such as fire disturbance, have been more important to permafrost stability, or the LIA might not be as severe a cold event in boreal western Canada as often assumed from paleoclimate records elsewhere. The ashfree bulk density shows a cyclic variation between $\sim$0.2 and 0.4 g/cm^3 with a periodicity of $\sim$1500 years. The periods with low density occur at 7, 5.3, 3.8, 2.4, 1.2 ka and the last 470 years, which are coherent in phasing relationship with wet events documented elsewhere in the region. It is remarkable to detect the 1500-yr periodicity here, considering the complex permafrost history of the peatland. This suggests that cyclic wet-dry climatic variations might have exerted dominant controls on permafrost dynamics and on fen-bog transitions. Our ongoing high-resolution macrofossil analysis will test the idea that the low bulk density periods represent high surface moisture and correspond with thaw layers or bog-to-fen switches. We hypothesize that moisture conditions might have been more important in driving complex ecosystem dynamics in permafrost peatlands during the Holocene and around the LIA than previously thought. Support of this hypothesis by our ongoing analyses is of significance in that it implies that the high uncertainty in projecting future precipitation-evaporation regimes will in turn make the prediction of future permafrost dynamics a challenging task.

GC23A-10 1330h POSTER

Wetlands and inundated surface variability over Canada and Alaska derived from microwave satellite data

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A new method for retrieving northern inundated and natural wetland area extent, from 19 and 37 GHz emissivities using the passive microwave Special Sensor Microwave/Imager (SSM/I) brightness temperature database, is proposed. The cumulated fraction of the water surface per pixels (area $<$ 25 x 25 km^2), computed on a weekly basis and averaged over the 1988-2001 period, gives a maximum of summer extent of 11.6 10^5 km^2 for Canada and Alaska, from 5% to 40% higher than different existing global data sets for the same region. The derived mean seasonal dynamics of wetland and inundated surface, concentrated between 48-68°N over North America, shows a maximum area extent during the months of July-August-September. The interannual anomaly variations of the inundated surfaces over Canada and Alaska are analyzed according to climatic variability since the last two decades (from 1979 to 2002). Such an observed parameter can be used to validate surface energy and hydrological budget of regional climate model.

GC23A-11 1330h POSTER

Ecological Assimilation of Land and Climate Observations - the EALCO model

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Ecosystems are intrinsically dynamic and interact with climate at a highly integrated level. Climate variables are the main driving factors in controlling the ecosystem physical, physiological, and biogeochemical processes including energy balance, water balance, photosynthesis, respiration, and nutrient cycling. On the other hand, ecosystems function as an integrity and feedback on the climate system through their control on surface radiation balance, energy partitioning, and greenhouse gases exchange. To improve our capability in climate change impact assessment, a comprehensive ecosystem model is required to address the many interactions between climate change and ecosystems. In addition, different ecosystems can have very different responses to the climate change and its variation. To provide more scientific support for ecosystem impact assessment at national scale, it is imperative that ecosystem models have the capability of assimilating the large scale geospatial information including satellite observations, GIS datasets, and climate model outputs or reanalysis. The EALCO model (Ecological Assimilation of Land and Climate Observations) is developed for such purposes. EALCO includes the comprehensive interactions among ecosystem processes and climate, and assimilates a variety of remote sensing products and GIS database. It provides both national and local scale model outputs for ecosystem responses to climate change including radiation and energy balances, water conditions and hydrological cycles, carbon sequestration and greenhouse gas exchange, and nutrient (N) cycling. These results form the foundation for the assessment of climate change impact on ecosystems, their services, and adaptation options. In this poster, the main algorithms for the radiation, energy, water, carbon, and nitrogen simulations were diagrammed. Sample input data layers at Canada national scale were illustrated. Model outputs including the Canada wide spatial distributions of net radiation, evapotranspiration, gross primary production, net primary production, and net ecosystem production were discussed.

GC23A-12 1330h POSTER

Study on the spatial distribution of annual continental evapotranspiration over China using LUCC data

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The spatial distribution of continental evapotranspiration over China was simulated using LUCC (Land Use and Cover Change) data of recent 10 years by routine evaporation models based on SPAC (Soil-Plant-Atmosphere-Continuous) system and mathematics interpolation models, additionally meteorological data of 621 weather stations from 1991 to 2000 in China was used. Three evapotranspiration grid maps in which each pixel presents 1 km were generated and they are the spatial distribution maps of annual continental

evapotranspiration in 1991,1995 and 2000. their distributed characteristics show that evapotranspiration of eastern areas is larger than that of western areas, and the areas of low latitude is larger than the areas of high latitude, annual evapotranspiration of western regions is very small. By means of studying the spatial and temporal variation of evapotranspiration and the associated impact factors, LUCC is the key factor affects regional evapotranspiration of China besides climate, precipitation, human activity. From 1991 to 1995 and 2000, actual month evapotranspiration of most areas shows a trend to increase, actual annual evapotranspiration also shows a trend to increase, especially arid and semi-arid regions show more obvious trend.

GC23A-13 1330h POSTER

Mapping landcover distribution over Canada from Earth Observation data for climate change studies

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We describe the application of earth observation (EO) data for land use and land cover change. Land cover change is identified by IPCC among the causes, or key forcing factors of global change. It is representative of the means by which human adaptation to these changes will occur. This research is part of the Earth Science for National Action on Climate Change project integrated into the NRCan/ESS Climate Change Program and supported by the Canadian Space Agency through Government Related Initiatives Program. The analysis of land-use & land cover changes is approached from three complementary perspectives: 1) monitoring, 2) providing earth observation based spatially explicit input for modeling of processes and 3) assessment of impact on ecological functions. The research is conducted at two spatial scales: regional scale based on 1km resolution data (AVHRR, SPOT VEGETATION, MODIS) and landscape scale, based on medium resolution 30 m data (Landsat ETM/TM and ASTER). The results presented here allow for qualitative assessment of changes in land cover over the Canadian landmass for period 1990-2000. Three land cover maps were produced from enhanced AVHRR surface reflectance time series data. The base map derived from 1995 AVHRR seasonal data was updated backward to produce 1990 and forwarded to produce 2000 land cover maps using a change detection and local classification methodology. Changes for 1990-1995 and 1995-2000 were generated using temporal change detection that employs 10-day composites for the summer seasons. Areas of significant change were extracted using ecoprovince specific thresholds set by comparison with Landsat and provincial fire databases. To classify change areas, local spectral signatures were generated around the change area based on the 1995 landcover map and spectral data for the year to be updated. The pixels within the change area were then classified using these signatures. The approach taken for producing these land cover data ensures its consistency and continuity while the unique classification legend allows for comparison and monitoring. These land cover products will be used for evaluating: 1) climate impacts, by coupling remote sensing-based land cover change data to atmospheric data - through Soil-Vegetation-Atmosphere thrasher models; 2) impact of fires on vegetation structure and phonology; and 3) environmental impact of industrial and infrastructure development

GC23A-14 1330h POSTER

Effect of Land Cover Change on Annual Rainfall Over South East Asia

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Global Vegetation Cover is strongly related to the climatic conditions. The strong effect of the rainfall has been found in controlling the global vegetation cover and agricultural crop yield. Based on the rainfall forecast the productivity of the crops and also the drought conditions are being monitored on routine basis. Since past several decades efforts have been made to understand the role of tropical forcing in the maintenance of general circulation in the atmosphere. It has been found that the low latitude condensation process and lateral coupling with the higher latitude energy shows as the most important driving force in the tropics. In the present paper, we have studied the variability of rainfall and vegetation in the South East Asian region. Nineteen years of vegetation and rainfall data have been analyzed using combined EOF and Fourier decomposition for different land cover in this area. Significant dependence of seasonal rainfall variability over vegetation in key areas - where vegetation leads rainfall - has been found. It has been found that cropland in the South Asian Region controls the variability of rainfall in this region.

GC23A-15 1330h POSTER

Radiative Forcing - Measured at Earth's Surface - Corroborate the Increasing Greenhouse Effect

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The Intergovernmental Panel of Climate Change (IPCC) confirmed concentrations of atmospheric greenhouse gases and radiative forcing to increase as a result of human activities. Nevertheless, changes in radiative forcing related to increasing greenhouse gas concentrations could not be detected with instrumental measurements at Earth's surface so far. Here we show that atmospheric longwave downward radiation significantly increased (+5.2 Wm^{-2}) partly due to increased cloud amount (+1.0 Wm^{-2}), while solar shortwave radiation decreased (-2.0 Wm^{-2}) over eight years of measurements at eight radiation stations distributed over the central Alps. With cloud effects subtracted, GCM model calculations show the cloud-free longwave flux increase (+4.2 Wm^{-2}) to be in due proportion to the increase of temperature (+ 0.82°C) and absolute humidity (+0.21 g m^{-3}), but to be three times larger than expected from anthropogenic greenhouse gases. The unexpected large increase of temperature and radiation fluxes was first thought being related to rising warm air advection under strengthened NAO conditions. However, recent investigations, which include measurements of 2003, show increased warming rather during summer time and no correlation with NAO. High correlation instead is found between temperature increases and the steady increase of total surface absorbed radiation, indicating that the fast temperature increase in central Europe is driven by a rapid increase of the greenhouse effect.

GC23A-16 1330h POSTER

Surface Meteorological Measurements Over Arctic First Year Ice During CASES 03-04

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During the over-wintering phase of CASES 03-04, Canada's new scientific icebreaker, the CCGS Amundsen, was frozen into the ice of Franklin Bay. The ship provided a base for measurements of surface meteorological parameters and fluxes from posts and towers set up on seasonal sea ice about 1.5 km from the ship, at approximately 70 deg 2.5' N, 126 deg 15.9' W, from mid January to April 2004. Basic measurements provide wind and temperature (air-snow-ice-water) profiles, visibility, irradiance, emittance and humidity data plus eddy correlation flux measurements. Two specific areas of attention are, 1) CO2 fluxes from the air to the snow surface, and 2) Drifting and blowing snow. Initial findings show a significant flux of CO2 to the surface and large numbers of particles in suspension in the air during blowing snow events. The CO2 fluxes are believed to be influenced by temperature-brine salinity relationships within the snow and ice while snow depth, density and structure are modified by drifting and blowing snow events.

GC23A-17 1330h POSTER

Neural Network Approach to Understanding Climate Feedbacks in the Arctic Ocean

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Feedback processes are believed to play an important role in the Arctic region and to be responsible for the polar amplification of global warming found in climate models. However, it is difficult to quantify the important feedback loops because of the many interactions among the relevant climate variables, particularly the nonlinear behavior of these interactions. The Jacobian of a neural network (NN) represents the first derivatives of output variables with respect to input variables and can be interpreted as sensitivities. It allows us to quantify the relationships among climate variables and to explore feedbacks. We apply this technique to investigate Arctic climate variables in winter at the SHEBA (Surface Heat Budget in the Arctic Ocean) site in the Beaufort Sea. Data collected during the SHEBA experiment, as well as retrievals from satellite measurements and output from a global climate model (GCM) are used to examine cloud-radiation feedbacks. Output from the NN is compared with a classical multivariate regression approach. The Jacobians of the NN are obtained for the three different data sources (in situ, satellite, and GCM), and compared with each other. These Jacobians are used to quantify climate sensitivities and to determine whether the climate model represents feedbacks realistically.

GC23A-18 1330h POSTER

The State of Lakes in Northern Ungava Peninsula During the Last 200 Years: a Picture of Recent Environmental Stability

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In the last decade, paleolimnological studies have shown that lacustrine ecosystems in many arctic regions are presently experiencing noticeable changes, likely brought about by recent, in part human-induced, climatic warming. Lakes are a major component of northern landscapes and their sensitivity to variations in their catchments make them reliable recorders of past local and regional environmental conditions, which are typically reflected in the microfossil assemblages that accumulate in lake sediments. The high-resolution study of subfossil diatom (siliceous algae) and chironomid (Diptera) remains from a series of lakes along Ungava Peninsula's northern coast, however, indicates that many limnological variables, including inferred dissolved organic carbon, alkalinity and water temperature, have remained relatively stable during the past 200 years, and beyond. Thus, unlike Alaska or the Canadian High Arctic, important limnological changes in the freshwater ecosystems of northern Québec and Labrador have yet to be observed, demonstrating the complexity and non-homogeneity of climatic variation in these northern regions. The remarkable stability at timescales of decades to centuries suggests that northern Québec and Labrador lakes may experience less short-term or delayed climatic change relative to other sectors within the Canadian Arctic. This "lag" in the warming trend between the northwestern and northeastern regions of North America seems analogous to the one documented during the final stages of the last deglaciation. Paleo-records dating from this period of time that investigate how these lakes evolved throughout the post-glacial warming phase, may therefore yield important insights into the climatic properties and dynamics of future climate in northern North America. Because freshwater ecosystems in northern Québec will likely experience drastic changes in the near future, they offer a unique opportunity for monitoring these changes in great detail. This aspect will in fact be the primary focus of our research program during the coming years.

GC

GC23A-19 1330h POSTER

Climate, Water and Renewable Energy in the Nordic Countries

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Climate and Energy (CE) is a new Nordic research project with funding from Nordic Energy Research (NEFP) and the Nordic energy sector. The project has the objective of a comprehensive assessment of the impact of climate variability and change on Nordic renewable energy resources including hydropower, wind power, bio-fuels and solar energy. This will include assessment of the power production of the hydropower dominated Nordic energy system and its sensitivity and vulnerability to climate change on both temporal and spatial scales; assessment of the impacts of extremes including floods, droughts, storms, seasonal patterns and variability. Within the CE project several thematic groups work on specific issues of climatic change and their impacts on renewable energy. A primary aim of the CE climate group is to supply a standard set of common scenarios of climate change in northern Europe and Greenland, based on recent global and regional climate change experiments. The snow and ice group has chosen glaciers from Greenland, Iceland, Norway and Sweden for an analysis of the response of glaciers to climate changes. Mass balance and dynamical changes, corresponding to the common scenario for climate changes, will be modelled and effects on glacier hydrology will be estimated. Preliminary work with dynamic modelling and climate scenarios shows a dramatic response of glacial runoff to increased temperature and precipitation. The statistical analysis group has reported on the status of time series analysis in the Nordic countries. The group has selected and quality controlled time series of stream flow to be included in the Nordic component of the database FRIEND. Also the group will collect information on time series for other variables and these series will be systematically analysed with respect to trend and other long-term changes. Preliminary work using multivariate analysis on stream flow and climate variables shows strong linkages with the long term atmospheric circulation in the North Atlantic. The hydrological modelling group has already reported on “Climate change impacts on water resources in the Nordic countries - State of the art and discussion of principles”. The group will compare different approaches of transferring the climate change signal into hydrological models and discuss uncertainties in models and climate scenarios. Furthermore, comprehensive assessment and mapping of impact of climate change will be produced for the whole Nordic region based on the scenarios from the CE-climate group.

GC23A-20 1330h POSTER

Quantitative Paleoclimate Reconstruction From Pollen Assemblages Preserved in Arctic Lake Sediments

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Surface sediment pollen assemblages from 390 lakes in northwestern Canada, northern Québec, the Canadian Arctic Archipelago and Greenland have been analyzed in order to provide modern analogs for quantitative paleoclimatic reconstruction. This represents a modern environmental gradient spanning 2400 mm of mean annual precipitation, 14.7° C of July temperature, and 32.7° C of January temperature. The modern pollen data includes relative frequencies of the 35 most common taxa. Correspondance analysis (CA) was used to explore spatial distribution of pollen assemblages and relationships with climatic parameters. The CA demonstrates a clear latitudinal pattern, with Axis 1 (27.1% of variance) positively and disgnificantly correlated (r=0.85) with July air temperature. The use of closest modern analogues for quantitative paleoclimatic reconstruction was evaluated by estimating modern climate from surface pollen spectra. The best results were obtained using a chord distance dissimilarity metric and the 5 closest analogues. Observed versus estimated modern variables produced root-mean-squared errors of prediction (RMSEP) of ±1.98° C and ±0.71° C for the January and July temperatures, respectively, and ±175.32 mm for annual precipitation. Detailed pollen analyses and paleoclimate reconstructions have been undertaken on Holocene sediments from two well dated lake cores on Cumberland Peninsula, Baffin Island. Squared chord distances between successive pollen spectra were first used to identify times of rapid vegetation change. Notable transitions occurred at 8000, 3000 and 500 cal BP. Although climate reconstructions from both sites indicate some local differences, there are generally consistent features on a regional scale, including a progressive 1.5° C decrease in July temperature since 8000 cal BP, a progressive 5° C increase in January temperature since 7000 cal BP and an increase in annual precipitation. These reconstructions are therefore consistent with a progressive reduction in the seasonal amplitude of Holocene paleotemperatures, which is tentatively attributed to enhanced oceanic influences at the regional scale.

GC23A-21 1330h POSTER

Inter-Annual Variability of Water Vapor and its Relation with the Onset of Monsoon

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The seasonal and inter-annual variability of total precipitable water (TPW) deduced from Special Sensor Microwave Imager (SSM/I) satellite over oceanic regions around the Indian sub-continent during 1991 - 2000 show characteristic behavior. The TPW over the Arabian Sea is found to be closely related to climate dynamics and the onset of the monsoon which first manifests over the Kerala coast around May and June. The TPW anomaly during the monsoon period over the Bay of Bengal is found to be lower than that of the Arabian Sea for the same latitudinal zone. Low water vapor anomaly over the Bay of Bengal is likely to be related to the existence of finer aerosol particles compared to the Arabian Sea. The spatial and temporal variation of aerosol over the Bay of Bengal and over the Arabian Sea will be presented. The sea surface temperature (SST) anomaly during the year 1991-2000 is found to be very dynamic and shows consistent relation with the water vapor anomaly for the same latitude. The maximum peak of TPW appear 5 to 10 days lag with that of the SST. The water vapor deduced from SSM/I is compared with the water vapor retrieved from the IRS-P4 MSMR and NOAA-NCEP data. The use of water vapor data will be discussed for forecasting the onset of Indian monsoon.

GC23A-22 1330h POSTER

”Smoky” Days in the Canadian Rockies, 1907-1925

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The incidence of forest fires may be a proxy for climate, but consistent records are scarce before the widespread use of aerial photography in the mid-20th century. During his tenure as fourth Secretary of the Smithsonian Institution (1907-1927), Charles D. Walcott spent 19 summers as a paleontologist in the Rocky Mountains, all but two of them in the Canadian Rockies west and northwest of Calgary. Prior to becoming Secretary, Walcott had been the second Director of the U.S. Geological Survey, with responsibility for the Forest Reserves established by Presidents Cleveland and McKinley. Walcott was frequently quoted in the newspapers on the subject of forest fire. During the 17 Canadian summers, Walcott camped an average of 86 days per summer, measured from the date he made his first camp to the date he broke his last camp of the summer. He wrote brief daily comments in diaries that did not change in size or style. The small diary page began with a pre-printed prompt to describe the weather, and there were summers when Walcott frequently wrote ”Smoky” at the start of diary entries. Here is a summary of eight Canadian summers (two 4-yr sets), with inclusive dates of his camping: 1908(26Jun-19Sep)was wet or clear until 1, 2, 3 Aug when he reports ”forest fire”, a rumor that Fernie, B.C., had been ”destroyed by fire”, and ”RR station at Fernie burned”. 9, 10 Aug had ”Smoky atmosphere”. On 6 Sep, ”Mr Clark left us to go & fight a forest fire.” 1909(18Jul-8Sep) has only one mention of ”forest fire” (13 Aug). This was the summer when Walcott discovered the Burgess shale fossils. 1910(28Jun-13Sep) contains no diary record suggesting forest fire. This was a summer when Walcott exploited the Burgess shale fossils. 1911(6Aug-21Sep) was the shortest of Walcott’s field seasons, most of it on the Burgess shale quarry, with no record relating to forest fire. 1922(23Jun-1Oct) reports ”Smoky” on 30 Jun, 1, 2, 3, 18, 19, 20, 21, 28, 29, 30, 31 Jul, and 1, 2, 3, 4, 5, 6, 9, 28, 29 Aug. 1923(5Jun-24Sep)lacks any indication of forest fire. 1924(3Jul-25Sep) was a cold wet summer, but with ”Fine day Smoky” and Half cldy &smoky” on 16, 17 Sep. 1925(5Jul-21Sep) mentions ”Smoky” on 16, 17, 19, 20, 212, 22 Jul, and on 5, 12 Aug, ”dense smoke” on 18 Jul, ”a blaze” on 1 Aug, ”smoke dense” on 3 Aug, and ”forest fire smoke” on 4 Aug. The diary entries suggest that forest fires occurred with a bimodal distribution: either none at all, or multiple incidents in a given summer. Per day camped, the entries suggest that July and August were smokier than September, and hint that fires in August were closer to Walcott than fires in July. Weather and recent fire history determine likelihood of forest fire, but Walcott’s desire for photographs, the elevation of his camp, his health, and competition for the small diary space from other events worth recording must have affected the degree to which Walcott noted evidence of forest fire. However, these consistent and continuous records by one competent observer, in one locality, during the same season, using the the same diary format have unusual value in providing evidence of smokey atmosphere in the first quarter of the 20th century. This study grew out of a close reading of E.L.Yochelson’s two-volume biography (1998-2001) of Walcott, and it depends on my reading the original diaries at the Smithsonian Archives.

GC41A CC: 220 C-E Thursday 0830h

Continental Energy Balance, Land-Surface Processes, and Surface Temperature I Posters

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

GC41A-01 0830h POSTER

A Multidisciplinary Approach to Assessing the Causal Components of Climate Change

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Separation of climate forcing by anthropogenic greenhouse gases from natural radiative climate forcing is difficult because the composite temperature signal in the meteorological and multi-proxy temperature records cannot be resolved directly into radiative forcing components. To address this problem, we have initiated a large-scale, multidisciplinary project to test coherence between ground surface temperatures (GST) reconstructed from borehole T-z profiles, surface air temperatures (SAT), soil temperatures, and solar radiation. Our hypothesis is that radiative heating and heat exchange between the ground and the air directly control the ground surface temperature. Consequently, borehole T-z measurements at multi-year intervals spanning time periods when solar radiation, soil and air temperatures have been recorded should enable comparison of the thermal energy stored in the ground to these quantities. If coherence between energy storage, solar radiation, GST, SAT and multi-proxy temperature data can be discerned for a one or two decade scale, synthesis of GST and multi-proxy data over the past several centuries may enable us to separately determine the anthropogenic and natural forcings of climate change. The data we are acquiring include: (1) New T-z measurements in boreholes previously used in paleoclimate and heat flow research in Canada and the United States from the 1970’s to the present. (2) Meteorological data from the US Historical Climatology Network and the Automated Weather Data Network of