conditions that facilitated the biodegradation of PCE. Carbon isotope data in VOC will confirm the role of PCE biodegradation in the plume.

H31G-03 0900h

Groundwater Flow and Salt Transport at a Sand Tailings Dam: Field Observations and Modelling Results.

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Large volumes of sand tailings are produced during the extraction of bitumen from the oil sands of Northeastern Alberta. The long-term groundwater response and subsequent movement of water and solutes within the large permeable sand tailings storage areas is uncertain. At the Southwest Sand Storage (SWSS) Facility, located at Syncrude's Mildred Lake operations near Ft. McMurray, there is concern that salts from the tailings water may discharge to newly placed reclamation material that covers the sand tailings. This saline discharge water could destroy the reclamation soil structure and negatively impact vegetation. The steady-state groundwater flow and transient movement of salts at the local (bench and slope) and intermediate (pile) scales in the SWSS are investigated. Water levels, seepage and groundwater quality (including TDS) have been measured for over a year along two transects of piezometers installed in the SWSS. The field data have been used to complete traditional hydrogeological interpretations of the site, and to develop a conceptual model of flow and transport. The local and intermediate flow systems and salt transport in the dam are being evaluated with numerical models. The models will allow possible future hydrogeological behaviour of the structure to be tested. Preliminary results show differences in flow systems and salinity distribution that depend on the deposition of the SWSS. This research will facilitate better long-term environmental management of this and similar sites.

H31G-04 0915h

Ecohydrological Controls on Natural and Drained Peatland Methane Emissions: Implications for Climate Change

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As natural sources of methane (CH_4), peatlands play an important role in the global carbon cycle. Increased evapotranspiration and lower water tables at many northern peatlands under a 2 x CO_2 scenario are predicted to lead to lower CH_4 emissions. Additionally, changes in water table position may encourage shifts in the vegetation community and the impact of this on CH_4 emissions must also be determined. This study examines the CH_4 emissions, gross ecosystem photosynthesis (GEP) and water table position during 2001-2002 for natural and drained (eight years prior) sites within a poor fen in central Québec. Growing season CH_4 emissions at the drained site were 55% lower than the control site primarily due to significantly reduced flux at topographic highs (up to 97% reduction), while the flux from topographically low areas remained high. The maintenance of high fluxes at these hollow sites was related to hydrological and ecological effects of the water table drawdown. The removal of standing water removed a potential zone of CH_4 oxidation and also enabled plant colonization at these locations leading to an increase in GEP. At the hollow sites, seasonal CH_4 emissions were significantly correlated to seasonal GEP (R^2=0.85). These results suggest that the response of northern peatland CH_4 dynamics to climate change depends on the antecedent moisture conditions of the site. Moreover, ecological succession can play an important role for determining CH_4 emissions, particularly from wetter sites.

H31G-05 0930h

Using Climate Station and Gridded Data for Modelling Daily Streamflow of a Large Mountainous Catchment

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Mountainous catchments consist of a complexities of landscape and the application of macro-hydrological models requires climatic data commensurate with the influence of the rugged terrain. The SLURP model was applied to a mountainous catchment (Liard basin) in northern Canada, using three sets of Canadian data to examine the effects of climatic input on streamflow simulation. Climatic stations in and around the Liard catchment provide in situ temperature and precipitation records for the model runs. Spatially gridded data from a Canadian regional climate model as well as from a weather forecast model of the Canadian Meteorological Centre were also applied to the basin. The use of climate stations and climate models produced similar Nash-Sutcliffe values ranging from a R2 of 0.87 to 0.85. The ability of SLURP to simulate the correct timing and magnitude of hydrograph rises, peaks and summer flows varies depending on the temperature and precipitation fields of the three data sets. This suggests that the climatic input data have notable effects on streamflow simulation for the mountainous environment.

H31G-06 0945h

Differential Atmospheric Controls on Transpiration of Boreal Trees: A Potential Factor in Pre-mature Tree Mortality in Green-Tree Retention Strategies

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Green-tree retention, a harvesting strategy that involves the preservation of isolated and interconnected patches of live trees within the boundaries of harvested areas, is assumed to emulate natural disturbance, while preserving forest canopy continuity for wildlife habitat, maintaining forest biodiversity, and many other landscape level objectives. Unfortunately, many of the retention trees die within a few years after harvesting, thus much of the desired function of these trees is lost. This research focuses on understanding the relationship between changes in microclimate following harvesting and transpiration, potentially leading to drought-induced mortality of aspen, balsam poplar, white spruce, and white birch. Continuous measurements of whole-tree water use (sap flow) and micro-climate were taken before and after harvesting of two adjacent boreal mixedwood stands in west-central Alberta in the summer of 2003. Differences in micro-climate including radiation, air temperature, relative humidity and wind penetration into the canopy produced large differences in atmospheric moisture demand (PET) between partially harvested (green-tree retention) and undisturbed forest canopies. The variability in atmospheric conditions created large differences in sap flow velocity and transpiration rates among these four boreal species. Differential transpiration rates among species will be discussed in context of atmospheric controls on water use and drought tolerance of boreal trees with differing autecology and/or hydraulic architecture.

H32A CC: 520 F Wednesday 1030h

Estimating the Flux of Freshwater From the Pan-Arctic Landmass I

(joint with A, OS)

Presiding: **R Lammers,** University of New Hampshire**; A Shiklomanov,** University of New Hampshire**; T Prowse,** University of Victoria

H32A-01 1035h

Model-based estimation of river flows to the Arctic Ocean

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Land surface models capable of representing the role of vegetation and land cover on the dynamics of the surface water balance and land-atmosphere energy exchanges are now used in most weather prediction and climate models. These models have been used in both off-line and coupled model to evaluate the effects of land cover and climate change at scales ranging from large river basins to global. The effects of climate and land cover change are key concerns in the pan-Arctic region, especially since most climate models predict that the region will be particularly sensitive to global warming. Nonetheless, land surface models have not been as well evaluated as elsewhere globally. Arctic hydrology, for instance, differs from that of more temperate regions, primarily because of the cold temperatures, dominance of snow cover and spring snowmelt floods, the presence of permafrost, and prevalence of lakes and wetlands. We describe a set of simulations with the Variable Infiltration Capacity (VIC) model implemented at 100 km spatial resolution across the pan-arctic domain that is intended to evaluate the model's representation of arctic processes. For a 20-year simulation (1980-99) we diagnose model simulations using observations of key processes simulated by the model, including: 1) comparison of snow cover extent with satellite-based estimates from the NOAA Northern Hemisphere weekly snow cover extent data; 2) summer permafrost maximum active-layer thickness from the Circumpolar Active Layer Monitoring (CALM) network site data; and 3) stream gauge observations of discharge at over 70 locations that constitute the outlets of major river basins and internal confluences. For the 20-year study period, we then produce an estimate of the annual mean freshwater inflow to the Arctic Ocean and its spatial distribution, which we compare with previous estimates.

H32A-02 1050h

Estimates of River Discharge to the Arctic Ocean and Northern Seas

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Several estimates of pan-Arctic freshwater flux to the ocean are made using observed river discharge data, modeled results, and a composite of the two. For observed data we report on an updated version of the R-ArcticNet river discharge database. This database now contains over 5000 gauges from Alaska, Canada, Scandinavia, and Russia. Modeled results use the Permafrost Water Balance Model (P/WBM) to characterize runoff, and other key hydrological variables, throughout the pan-Arctic region. The composite runoff field uses a hybrid of the observed data and modeled results to provide a "best guess" river discharge estimate. All estimates are carried out using the 25 km resolution digital river network based on the NSIDC Northern Hemisphere EASE grid. This river network contains over 3089 drainage basins within 18 Sea Basins throughout the pan-Arctic drainage system. An intercomparison of the different methods of estimating discharge to the ocean provides us with a range in expected outcomes which will yield those regions with increased uncertainty in discharge. The resultant database will be of use to Arctic Ocean modelers and those interested in the flux of freshwater continental shelves in the Arctic Seas.

H32A-03 1105h

On Connections between the Atmosphere, Runoff and Arctic Shelf Marine Environment with Focus on the East-Siberian Region.

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Analysis of temperature records in North Asia and North America shows that over the last 30 years the warming is as much 2°C/decade in winter. The ongoing changes in the regime of the pan-Arctic rivers due to global change are pronounced strongly in North Asia and North America both. We consider the long-range variability in the riverine discharge as an indicator of climate regional change that is coincident also with a long-range increase of the Siberian river-runoff of about 165 km3, permafrost warming, change in ice growth rates in the Arctic, decrease in the Arctic Sea ice extent, strengthening of the Arctic Oscillations and North Atlantic oscillations after 1970. Our study identifies changes in seasonal variability of the Siberian river discharges in the second half of the 20th century. In this report we are looking mostly for connection among atmosphere, runoff, and marine environment (including sea ice) in the poor explored East-Siberian region using historical datasets and our original field data (1995-2003). First time the long-term oceanographic data are compared with the bottom sediment isotope data that allows to study change in position of boundary between the Pacific derived waters and "local" shelf waters (diluted by the Lena and other rivers). In the past three decades mean values of annual discharge increased for Great Siberian rivers :Ob, Yenisey and Lena by 5.7%, 6% and 3%, respectively. Same time, the mean value of winter discharge has increased by 13% for the Ob, 45% for the Yenisey, and 25% for the Lena. The seasonal redistribution of the river discharge of the Yenisey, Ob, and Lena might be connected more or less with hydropower development (dams). Anyway, due to winter discharge total annual Siberian river input into the Arctic has increased by 4.5% during the 1970-2000 in comparison with the period 1945-1970,. In the second half of the 20th century the Siberian rivers delivered 0.03 - 0.07 Sv (1 Sv=106m3/s) of freshwater into the Arctic Basin annually. This is comparable to the mean annual production of bottom water on the shelves surrounding the Canadian Basin (about 0.05 Sv), which enters the intermediate depth layer. On average in the cold season 0.01 Sv of riverine freshwater and 0.04 Sv in summer enter the Siberian shelf. Our evaluation shows that from 1970 to 1999 a mean river input (Ob, Yenisey, and Lena) to the Siberian shelves has increased of about 0.003-0.006 Sv. Discharge anomalies between the Lena, and Ob and Yenisey shows synchronous variability until the climate shift of early 1970s, when drastic increase of Great Siberian river's wintertime discharge was obtained. It agrees quantitatively with the cumulative ice production over the East-Siberian polynyas. The calculated correlation matrix between cumulative curves of ice-condition in the Siberian seas, the ice export through Fram Strait, and the Lena discharge shows the best correlation for time lag of 4, 5 and 6 years, because it is a sum of time needed for riverine water extension onto the shelf and time for ice export to the Fram Strait. A spectral analysis of annual mean discharge shows maxima with periods of 2 yr, 3-4 yr and 6-10 yr in all Siberian rivers that agrees well with periodicity in the Vangengeim' indices of atmospheric circulation.

H32A-04 1120h

Freshwater Runoff to the Barents Sea Under Present and Future Climate Conditions

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Climatic changes may have a large impact on hydrological processes in the Arctic and sub-Arctic. Global warming may lead to a shift in the snowmelt season and more evaporation in summer, although these changes might be counteracted by an increase in precipitation. Changes in the land surface hydrology will in turn affect the discharge regime of the rivers and the amount of freshwater entering the Arctic Ocean. However, in analysing the impact of climate change on arctic river discharge, previous studies have been complicated by the fact that climate models are not able to realistically simulate lateral fluxes of water, nor the water balance of large river systems. Hydrological models are therefore indispensable in analysing the sensitivity of Arctic hydrology to climate change, but face limited data availability and usually have to rely on empirical process descriptions. In the present study we use a regional climate model to drive a physically based hydrological model of major river basins in Northern Europe draining towards the Barents Sea. This approach leads to a realistic simulation of hydrological processes, including snowmelt and river discharge, and a correct representation of the water balance and the discharge regime of these arctic and sub-arctic rivers. The first results indicate a shift in the snowmelt runoff peak in spring of about 20 days or more by the end of this century. However, the amount of discharge during peak flow remains more or less the same or shows only a slight increase. We also found a significant increase in the annual volume of freshwater runoff that, in some river basins, was proportionally larger than the projected increases in precipitation.

H32A-05 1135h

Lena River Water Propagation over the Eastern Part of the Laptev Sea Shelf

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The Lena River is one of the major sources of fresh water into the Siberian part of the Arctic Ocean. This study is focused on regularities of the Lena River waters propagation over the Laptev Sea shelf. Summer salinity (S), temperature (T) data and the Lena River runoff and temperature data are analyzed over the period 1965-2001. An integral approach of estimation salt and heat content of 5 m thickness layers was applied for several regions within the eastern Laptev Sea shelf. This part of the sea is under the permanent strong fluvial impact because 89 % of the Lena River waters come through eastern delta channels. The data analysis shows that cyclonic (CCR) and anticyclonic (ACCR) atmospheric circulation regimes essentially affect the propagation and redistribution of the Lena river runoff as well as different mechanisms of river and marine water interaction. There is a negative correlation between summer river runoff and surface layer salt content under CCR conditions implying that river discharge primarily controls the freshening of the surface water layer. Under CCR onshore winds prevent the northward propagation of the river plume. The river plume becomes thicker and stably stratified in comparison to ACCR conditions. It causes limited entrainment of ambient salty waters resulted in persistent negative correlation between river discharge and surface layer salt content. Under ACCR conditions the correlation between surface layer salt content and river discharge is positive. Offshore winds prevailing under ACCR result in considerable plume northward redistribution and weakening of the vertical density gradient. The positive correlation in this case suggests that the surface layer salt content under ACCR is strongly affected not only by the freshening due to riverine flux but also due to enhanced salinisation via the entrainment of the ambient salty waters. The heat content of surface layer is affected by both heat exchange with atmosphere and river heat flux. The study of heat fluxes is still under way.

H32B CC: 520 C Wednesday 1030h

Flow, Sediment Transport, and Stream Ecology I

Presiding: **A Roy,** Universit de Montral**; S Lane,** University of Leeds

H32B-01 1030h

Linking Sediment Transport to Coherent Flow Structures: First Results Using 2-Phase PIV and Considerations of the Origin of Large-Scale Turbulence

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The origin and scaling of large-scale coherent flow structures has been of central interest in furthering understanding of the nature of turbulent boundary layers, and recent work has shown the presence of large-scale turbulent flow structures that may extend through the whole flow depth. Such structures may dominate the entrainment of bedload sediment and advection of fine sediment in suspension. However, we still know remarkably little of the interactions between the dynamics of coherent flow structures and sediment transport, and its implications for ecosystem dynamics. This paper will discuss the first results of two-phase particle imaging velocimetry (PIV) that has been used to visualize large-scale turbulent flow structures moving over a flat bed in a water channel, and the motion of sand particles within these flows. The talk will outline the methodology, involving the fluorescent tagging of sediment and its discrimination from the fluid phase, and show results that illustrate the key role of these large-scale structures in the transport of sediment. Additionally, the presence of these structures will be discussed in relation to the origin of vorticity within flat-bed boundary layers and recent models that envisage these large-scale motions as being linked to whole-flow field structures. Discussion will focus on if these recent models simply reflect the organization of turbulent boundary layer structure and vortex packets, some of which are amply visualised at the laminar-turbulent transition.

H32B-02 1045h

The Numerical Simulation of Time Dependent Flow Structures Over a Natural Gravel Surface.

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Research undertaken over the last few years has demonstrated the importance of the structure of gravel river beds for understanding the interaction between fluid flow and sediment transport processes. This includes the observation of periodic high-speed fluid wedges interconnected by low-speed flow regions. Our understanding of these flows has been enhanced significantly through a series of laboratory experiments and supported by field observations. However, the potential of high resolution three dimensional Computational Fluid Dynamics (CFD) modeling has yet to be fully developed. This is largely the result of the problems of designing numerically stable meshes for use with complex bed topographies and that Reynolds averaged turbulence schemes are applied. This paper develops two novel techniques for dealing with these issues. The first is the development and validation of a method for representing the complex surface topography of gravel-bed rivers in high resolution three-dimensional computational fluid dynamic models. This is based upon a porosity treatment with a regular structured grid and the application of a porosity modification to the mass conservation equation in which: fully blocked cells are assigned a porosity of zero; fully unblocked cells are assigned a porosity of one; and partly blocked cells are assigned a porosity of between 0 and 1, according to the percentage of the cell volume that is blocked. The second is the application of Large Eddy Simulation (LES) which enables time dependent flow structures to be numerically predicted over the complex bed topographies. The regular structured grid with the embedded porosity algorithm maintains a constant grid cell size throughout the domain implying a constant filter scale for the LES simulation. This enables the prediction of coherent structures, repetitive quasi-cyclic large-scale turbulent motions, over the gravel surface which are of a similar magnitude and frequency to those previously observed in both flume and field studies. These structures are formed by topographic forcing within the domain and are scaled with the flow depth. Finally, this provides the numerical framework for the prediction of sediment transport within a time dependent framework. The turbulent motions make a significant contribution to the turbulent shear stress and the pressure fluctuations which significantly affect the forces acting on the bed and potentially control sediment motion.

H32B-03 1100h

Characterisation of 3D Hydrodynamic Flow Structures Associated With Instream Boulder and Pebble Clusters

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