B13A-03 1400h

Topographic Distribution of Soil Respiration in Northern Hardwood Forests

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Soil respiration is an important source of CO_2 to the atmosphere and fluxes from complex terrains like those found in northern hardwood forests are not well documented. Our initial hypothesis was that the wetlands (swamps) at the bottom of such catchments would exhibit consistently less CO_2 efflux than the upland components. To test this hypothesis we laid out transects along topographic gradients in each of two catchments at the Turkey Lakes Watershed near Sault Ste. Marie Ontario. Soil respiration was determined by the static non-steady state chamber method using an infrared gas analyser in the summer and fall of 2002 and spring to fall of 2003. Measurements of soil temperature, moisture and soil solution DOC concentrations were collected coincidentally with CO_2 efflux measurements. Results indicate that a transition zone exists at the lower portions of the slopes in these high relief catchments that is characterized by higher CO_2 efflux than the wetland or upland sites along the transects. The differences in CO_2 efflux are greatest in mid summer, e.g. August 2003 mean values were 9, 7 and 3 micromoles CO_2 m^{-2} sec^{-1} for the transition, upland and wetland zones respectively. Several topographic features (depressions, shelves, convergent and divergent foot slopes) populate the transition zone but collar placement did not specifically target them. Therefore statistical analysis was done on the three-position model defining the transition zone as simply the lower portion of the slope. On an annual basis the transition zone showed significantly greater effluxes of CO_2 than either of the other two zones ($P < 0.005$). Different topographic positions also exhibited differences in the relationships between CO_2 efflux and soil temperature, soil moisture and soil solution DOC concentrations. This study shows that soil respiration can not be generalized without taking topographic position into consideration. Classification of catchments simply into "wetland" and "upland" components is insufficient to accurately describe CO_2 effluxes in complex terrain. These results point to the necessity of mapping the distribution of topographic features in complex terrain so that their differential contribution to CO_2 efflux can be incorporated into carbon budget models.

B13A-04 1415h

Carbon and water exchange of a younger, drier deciduous forest compared to the long-term study site at Harvard Forest, Massachusetts

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We measured carbon and water exchange by the eddy covariance method at a younger, drier deciduous forest and compared it to the well-known Harvard Forest deciduous site during two growing seasons (2002 and 2003) and an intervening dormant season. Forests at both sites are dominated by red oak (*Quercus rubra*) and red maple (*Acer rubrum*), but the younger forest is situated near a hilltop, as opposed to the long-term Harvard Forest site, which is in a lowland area within 100 m of a stream and about 200 m from a bog. The younger forest had a maximum tree age of about 44 years within 200 m of the eddy flux tower (owing to an intense fire in the autumn of 1957); this compares to maximum tree ages of 65 to 90 years, depending on exact location, near the long-term site. The younger, drier forest stored about 1.7 Mg C/ha from May 2002 through April 2003. We estimate that this was about 30% less than annual storage in the older, moister forest at the long-term site, but as the 12-month periods on which this comparison is based are not completely overlapping for the two sites, this comparison may change slightly. Light-saturated net ecosystem carbon uptake of both sites was about 22 μ mol m^{-2} s^{-1} in June 2002, but by August the value for the drier site was only about 20 μ mol m^{-2} s^{-1} compared to about 24 μ mol m^{-2} s^{-1} for the long-term site, suggesting that water availability may have become a limiting factor for photosynthesis in the drier forest. At the younger site in 2003 compared to 2002, we estimated less C storage in May and June but more C storage in July, August and September, with an overall increase in growing season C storage of about 0.4 Mg/ha. Lower early-growing season in carbon storage in 2003 versus 2002 was associated with slightly lower net ecosystem carbon uptake at all light levels in June 2003 compared to a year earlier. Cloudy and cool weather in May and early June 2003 reduced C uptake directly by reducing light available for photosynthesis, and apparently also caused a delay in leaf maturation and the development of photosynthetic capacity in the trees' foliage.

B13A-05 1430h

Interannual Variability in CO_2 and Water Vapour fluxes from a Recently Harvested Site on the Canadian West Coast

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Forest harvesting and succession have a major impact on the dynamics of carbon and water vapour exchange between forests and the atmosphere. This presentation examines fluxes of CO_2 and water vapour measured using the eddy covariance technique for the first three years after clearcut harvesting and replanting of a coastal Douglas-fir stand on Vancouver Island, BC, Canada. To investigate the impact of changing weather and stand structure on annual and seasonal net ecosystem production (NEP) and evapotranspiration, relationships with biophysical variables such as light, temperature, soil moisture, and leaf area index (LAI) were developed. In all three years, the stand was a large source of atmospheric C (620, 520, and 600 g C m^{-2} y^{-1}). Over the three years, annual gross ecosystem production (GEP) increased from 220 to 640 g C m^{-2} y^{-1} but was exceeded by an increase in annual ecosystem respiration (Re) from 840 to 1240 g C m^{-2} y^{-1}. During this period, the growth of pioneer and understory species resulted in an increase in LAI from about 0.2 to 2.5 m^2 m^{-2}. Seasonal and interannual variations in GEP were well described by variations in photosynthetically active radiation and changes in LAI. Nighttime measurements of NEP (=-Re) exponentially increased with increasing 2-cm soil temperature with an average Q_{10} of 2 and R_{10} that increased from 2.1 to 2.5 to 3.2 μmol m^{-2} s^{-1} in the three years since harvesting. Although the re-establishment of vegetation in this stand had a major impact on both GEP and Re, interannual variations in evapotranspiration ($\pm$ 20 mm on an average 270 mm y^{-1}) were most affected by variations in weather, particularly in soil moisture. For example, drought late in the summer of the third year significantly reduced evapotranspiration and increased the Bowen ratio. This period of drought also resulted in early senescence of the vegetation and reduced both GEP and Re. As a result, there was less evapotranspiration and more atmospheric C lost from the stand in the third year after harvesting than in the second year.

B13A-06 1505h

Long-term and Seasonal Trends in Dissolved Organic Carbon Mass Balances in the Dorset, Ontario Study Lakes, 1978-1998.

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Mass balances of dissolved organic carbon (DOC) based on stream flows, precipitation inputs and lake outflows were measured for seven unproductive lakes in central Ontario between 1978 and 1998. Fluctuations in annual runoff over the 20 year period were similar in the seven study lakes in response to regional-scale climate variation. Responses of total DOC load (primarily export from catchments) and retained DOC (DOC load not discharged downstream) were also similar. There were similar but less accentuated variations in annual DOC concentrations. There were no clear regional trends evident during the 20 year period towards drier or wetter conditions, less DOC load, clearer lakes, etc. that could be interpreted as signaling a shift towards a different equilibrium state. The seasonal trend in mean monthly runoff was quite pronounced with peak discharge in each lake coinciding with spring melt in April and a much smaller peak in late fall/early winter. There were similar trends in DOC load and storage although the fall peaks in load were almost as large as the spring peaks in spite of much lower runoff, perhaps because of the presence of relatively large amounts of recently fixed, labile organic matter. Monthly DOC fractional retention increased in each of the lakes from lows in January and February to peaks in late summer/early fall. This has implications for the fate of DOC-bound contaminants: contaminants are more likely to be discharged downstream if they reach a lake during December-February. However, if the load contaminant-DOC ratio is constant during the year, than peak contaminant storage in terms of mass will coincide with DOC storage peaks.

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B14A CC: 524 A Monday 1530h

Measurement and Modeling of Carbon, Water, and Energy Exchange in Northern Ecosystems II

Presiding: **H Margolis,** Universit Laval**; C Coursolle,** Universit Laval

B14A-01 1530h

Net Ecosystem Exchange of Carbon Dioxide in a Temperate Poor Fen: A Comparison of Automated and Manual Chamber Techniques

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We used five techniques to compare Net Ecosystem Exchange (NEE) of carbon dioxide (CO_2) in a poor fen using automated and manual static chambers, and found the methods comparable. Once per week we sampled manually from ten collars with a closed chamber system using a LiCor 6200 portable photosynthesis system, and simulated four photosynthetically active radiation (PAR) levels using shrouds. Ten automated chambers sampled CO_2 flux every three hours with a LiCor 6252 infrared gas analyzer. Results of the five comparisons showed (1) NEE measurements made from May - August, 2001 by the manual and automated chambers had similar ranges: -10.8 to 12.7 μmol CO_2 m^{-2} s^{-1} and -17.2 to 13.1 μmol CO_2 m^{-2} s^{-1} respectively. (2) When sorted into four PAR regimes and adjusted for temperature (respiration was measured under different temperature regimes), mean NEE did not differ significantly between the chambers ($p<0.05$). (3) Chambers were not significantly different in regression of ln(-respiration) on temperature. (4) But differences were found in the PAR vs. NEE relationship with manual chambers providing higher maximum gross photosynthesis estimates (GP_{max}), and slower uptake of CO_2 at low PAR (α) even after temperature adjustment. (5) Due to the high variability in chamber characteristics, we developed an equation to include foliar biomass and water table as well as temperature and PAR, to provide a more direct comparison between automated and manual NEE. Comparing fitted parameters did not identify new differences between the chambers. These complementary chamber techniques offer a

unique opportunity to assess the variability and uncertainty in CO_2 flux measurements.

B14A-02 1545h

Surface Water and Heat Exchange Processes at a Swedish Peatland.

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Peatlands cover large areas of the northern boreal biome and have a significant importance in both regional hydrology and global climate context. However, open peatlands are poorly represented in physical descriptions and parameterizations for models of land surface processes, and very few attempts have been made to examine their functions. The main difficulty concerns the Sphagnum mosses which dominate the surface layer. The flux interaction between surface and the scarce canopy as well as the effects of hummock and hollow microtopography are also issues to be examined. A 1-dimensional SVAT model was used to simulate the energy exhange at a Swedish Sphagnum peatland with sparse canopy. Separate parameterizations and simulations were made for hummocks and hollows. The initially used soil parameters, derived from literature values, resulted in too low water contents in most layers. The estimated unsaturated hydraulic conductivity was also far too low to give correct descriptions of soil moisture variation and moss evaporation capacity. In the simulations, differences between wet and dry periods were overestimated and the moss surface had to be simulated as continuously moist and evaporating during both wet and dry periods to avoid overestimation of peat temperature. When the mosses were parameterized to be able to evaporate almost freely, the simulated total atmospheric fluxes agreed fairly well with measured fluxes. The description of hollow heat transport processes was good in saturated conditions but failed when water table dropped, probably because of peat compressibility effects. The results show that current soil property descriptions are not working properly for mosses and fresh peat and there is a call for alternative descriptions. Another dilemma was found in that there were indications that a one-dimensional approach of hummock processes may be improper, because of its three-dimensional appearance.

B14A-03 1600h

Climatic and radiative forcing consequences of peatland response to changing climatic conditions over decadal to millennial timescales

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We explore short- and long-term climatic radiative forcing consequences of CO_2 and CH_4 emissions from peatlands under varying climatic conditions. We couple output from the Peat Accumulation Model with empirical estimates of methane emissions and a first-order atmospheric perturbation model to assess relative impacts of peatland CO_2 and CH_4 emissions dynamics, accounting for differences in atmospheric lifetime and radiative efficiency. This provides a more dynamic and complete view of climatic impacts than a standard global warming potential analysis. We examine the first order effects of changes in moisture conditions in response to changes in the water balance, due to changes in the difference between precipitation and evapotranspiration. We also examine potential second order influences by changing the position of the water table relative to the peat surface, which could be caused by a drop in the peatland surface due to permafrost melting (i.e., collapse scars) and/or the burning of a peatland.

B14A-04 1615h

Photosynthesis Respiration Balance of Lakes

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Growing concern about global climate change necessitates an improved understanding of carbon cycling in aquatic systems. Aquatic ecosystems are net autotrophic and act as sinks for CO_2 if photosynthesis exceeds respiration. When respiration exceeds photosynthesis they are net heterotrophic and act as sources of CO_2 to the atmosphere. The relative importance of net primary productivity over community respiration in both marine and freshwater ecosystems has been a highly debated subject for many years. While some work has shown respiration to exceed photosynthesis in all but the most eutrophic ecosystems, others have found that photosynthesis is greater than respiration in even oligotrophic systems. Independent of these studies is the observation that most lakes are continually supersaturated with respect to CO_2. Previous work has shown stable isotopes of oxygen are an effective means of tracing the photosynthesis respiration balance of aquatic ecosystems. In an attempt to resolve the P:R balance of lakes we have applied this stable isotope technique to twenty-one lakes in Quebec with varying physiochemical properties. The lakes were examined on a monthly basis between May and October 2003 and the metabolic balance determined. Preliminary results indicate the P:R balance of the ice-free period to be near equilibrium, despite near continual supersaturation in CO_2.

B14A-05 1630h

Ebullition of biogenic gas bubbles from samples of near-surface peat.

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There is evidence that peat soils are not water-saturated below the water table (e.g. Rosenberry et al. 2003; Baird and Waldron, 2003), owing to accumulations of biogenic gas bubbles, consisting of poorly-soluble gases such as CH_4. It has been shown that gas bubbles can block pores and reduce rates of water flow in peat soils (Baird and Waldron, 2003). It has also been shown that, beyond certain levels, biogenic gas bubble accumulations become unstable, giving rise to large but episodic ebullition events, and that ebullition may be an important mechanism of CH_4 transfer between peat soils and the atmosphere (e.g. Romanowicz et al., 1995; Rosenberry et al., 2003). However, the studies that have been done on ebullition have looked at relatively deep peat where the bubbles were apparently held below a confining layer of low hydraulic conductivity. Very little is known about the degree to which gas bubbles accumulate in near-surface peat (i.e. the upper 40 cm) and whether they accumulate to such an extent that ebullition and transfer of carbon gases to the atmosphere occur. To address this lack of knowledge we conducted experiments on eight undisturbed' samples of near-surface (depths of c. 8 cm to 30 cm) peat taken from two lowland raised bogs, one in SW Scotland and one in W Wales. The samples were c. 10 l in volume and were incubated at 12 deg. C with the water table maintained above the sample surface. Water was allowed to flow through the samples periodically for the measurement of hydraulic conductivity (not reported here). Gas traps were fitted to the tops of the samples and the volume of gas in these was measured c. every 2-3 days. Finally, the samples were fitted with TDR probes and gas permeation samplers to measure gas volume and to take gas samples for the measurement of gas content (CH_4 and CO_2) using a GC. Ebullition was recorded in every sample but only after a build up of biogenic gas bubbles had occurred. We found that ebullition was not episodic and that it appeared to match gas production. The amount of ebullition varied substantially between samples. In two samples from the Scottish bog consisting respectively of *Sphagnum papillosum* and *S. magellanicum* litter, over 400 ml of gas per sample was lost over a 90-day period. At the other extreme, virtually no ebullition occurred from one of the Welsh peat samples, with only 14.5 ml being lost in 125 days. Provisional calculations based on CH_4 concentrations in our gas permeation samplers suggest that CH_4 efflux from the peatland surface via ebullition is potentially as important as that via diffusional transfer. We consider how transportable our data are to field conditions.

B14A-06 1645h

Development and testing of an improved model of the thermal behaviour of peat soils.

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Many biogeochemical processes in peats are temperature-sensitive. Despite this, little work has been done on characterising the thermal behaviour of peats. Most existing studies have looked only at 1-D thermal behaviour using simple models in which the thermal properties are constant with depth, and the temperature variation at the surface is specified from field measurements or is assumed to follow a sine wave. We report on the development and application of a more realistic thermal model of peat soils in which heat transfer is described by a system of capacitors' or nodes and resistors'. Its features include: 1. A realistic surface boundary condition where convective (sensible and latent) and radiative (short- and long- wave) heat transfers are accounted for by nodes representing the air/atmosphere above the peatland surface. 2. The ability to vary thermal properties with depth in order to simulate, for example, the effect of an unsaturated zone above the water table on thermal behaviour. 3. The ability to simulate 3-D patterns of heat transfer in patterned peatlands consisting of hummocks, lawns, hollows, and pools (microforms). In order that the model can be applied to a 3-D system, the standard large-scale parameterisation of the Penman-Monteith equation, used to calculate convective heat fluxes, has been improved. First, aerodynamic resistance has been calculated from newly developed sensitive self-logging atmometers, enabling measurement of potential evaporation at high frequencies and at different positions on and surrounding a microform, either at the ground surface or within the plant canopy. Secondly, dual probe heat pulse sensors (DPHPS) have enabled the measurement of soil thermal properties and volumetric water content of a small volume of soil at regular time intervals. In combination with measured water-table fluctuations, a stack of DPHPS within the unsaturated zone has enabled the accurate measurement of actual evapotranspiration, without the interference and labour requirements of a lysimeter. The model has been applied, in its 1-D form, to a *Sphagnum* hollow and lawn in order to evaluate these new approaches and to test the error that arises when advective heat transfer within the soil profile is ignored. Advective heat transfer has been ignored in the model because of the complex nature of unsaturated water transfer within *Sphagnum* litter and acrotelm peat. The prototype equipment enabled the successful parameterisation and accurate representation of the thermal behaviour of the *Sphagnum* hollow and lawn during dry periods. During wet periods model error increased slightly; however, negative feedback mechanisms at the surface boundary enabled the model to recover quickly. We discuss the future application of this model to a hummock-hollow complex and demonstrate how consideration of points 1, 2, and 3 above can lead to quite different patterns of heat transfer from those predicted in previous simple models.

B21A CC: 220 C-E Tuesday 0830h

Mercury Biogeochemistry at the Terrestrial-Aquatic Interface I Posters

Presiding: **B A Branfireun,** University of Toronto at Mississauga**; M Marvin-DiPasquale,** U.S. Geological Survey

B21A-01 0830h POSTER

Effects of Mercury Contamination on Visible and Near Infrared Reflectance Spectra of Vegetation in Connecticut

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Current techniques commonly used to survey metal-contaminated soils are expensive, time consuming and only applicable on a small scale. Remote sensing offers the possibility of a cost-effective method for detecting and mapping the extent of contamination. Although metals cannot be directly detected in vegetation, it may be possible to detect secondary effects of metal stress in plant leaves. The goal of this project is to discern the spectral signature of metals in vegetation in Connecticut. This study encompasses sites that are contaminated from both point and non-point sources of mercury and other trace metals. Elevated