biomass of arbuscular mycorrhizal hyphae was approximated as 43 Tg in bottom-up estimates and 140 Tg in top-down calculations. Thus, hyphal biomass was equivalent to only 0.3 to 1% of standing root biomass. However, the estimated total length of arbuscular mycorrhizal hyphae (18 x 10^{18} to 59 x 10^{18} m) was more than 20 times the length of their associated live fine roots. Temperate grasslands, savannas, and tropical rainforests contained the largest pools of arbuscular mycorrhizal hyphae. These budgets could assist researchers in predicting larger-scale responses of arbuscular mycorrhizal fungi–and ecosystems in general–to global change.

B22A-0807 1330h POSTER

Use of a Microarray to Detect Expression of Genes for Lignin-Degrading Enzymes in Soil Fungi

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Lignin is a complex biopolymer that is degraded by fungi. Several extracellular enzymes have been implicated in degradation and include lignin peroxidases, laccases, manganese peroxidases, and glyoxal oxidases. Versions of these enzymes are produced by multiple species of fungi, and in some cases, multiple versions of a single enzyme may be produced by the same species of fungus. Previous research has indicated changes in fungal activity and diversity along a tallgrass prairie restoration chronosequence (Fermi National Lab, IL). A cDNA microarray was designed to interrogate the expression and microbial source of these lignin degrading enzymes in the chronosequence soils. We hypothesized that less diversity in gene expression would be detected in a farmed soil than in a restored prairie soil. The array had 46 oligonucleotides (15-25mer) that represent each of the enzymes listed above. Messenger RNA was extracted from 32 one-gram subsamples of the target soils then all of the extracts were pooled prior to RNA precipitation and mRNA purification. Aminoallyl modified dUTPs were incorporated during reverse transcription, after which the cDNA was labeled with Alexa-555 dye. The labeled cDNA was hybridized with the microarray for 24 hours and then imaged. Preliminary results support the hypothesis that fewer genes were expressed in the farmed soil than in the restored soil.

B22A-0808 1330h INVITED POSTER

The Short-Wave Aerostat Mounted Imager (SWAMI): a Novel Hyperspectral Remote Sensing Instrument Platform

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The Short-Wave Aerostat Mounted Imager (SWAMI) is a newly designed remote sensing platform attached to the tether line of a 3500 m3 research balloon. We are using the SWAMI to study terrestrial ecosystems by bridging the spatial gap between radiometric measurements collected near the surface and those collected by other aircraft or satellite. Primary instruments of the SWAMI include an Analytical Spectral Devices Dual VNIR spectrometer, video camera, and thermal infrared sensor, which are mounted upon a pointable view hatch with active stabilization. Secondary instruments include a GPS receiver and numerous meteorological sensors. Downloads of sensor data and remote control of the spectrometer occurs via wireless transmission to a ground control station. The balloon can be flown at altitudes up to 2km AGL. Data collected during Summer 2003 over a ponderosa pine forest, a conifer forest/grassland ecotone, and grassland areas are being used to investigate spectral mixture algorithms commonly used in sub-pixel analysis. Portions of the SWAMI platform are planned for use at an Ameriflux tower site in the Black Hills of South Dakota to collect data relevant to SpecNet. Applications of SWAMI technology to the proposed SpecNet network, including wireless spectrometer control and active pointing control mechanisms, will be discussed.

URL: http://www.ias.sdsmt.edu/rsel/

B22A-0809 1330h POSTER

Automated Tram System for Ecosystem Optical Sampling in Flux Tower footprint

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The need for adding non-intrusive remote sensing methods within the flux footprint has led to the development of an automated tram system. The system consists of a cart on a100m track running through the flux tower's footprint. The cart instruments include a dual-detector spectrometer and thermal sensor that collect optical and thermal samples at specified positions repeatedly over time. The two detectors allow correction for changing light conditions (e.g. clouds), and the addition of a programmable micro-controller allows the system to know its position and the time and date the data were collected. The cart also has the capabilities to recharge itself and shut down between sampling intervals, send data to a base station through a wireless link, and ultimately be controlled from a lab station through the internet. Automation of the system eliminates the disturbance that a field investigator would introduce as well as the need of regular field site visits. This system allows spatially and temporally explicit sampling of ecosystem optical and thermal properties within the flux tower footprint, improving our understanding of the controls on ecosystem carbon flux.

B22B MCC: 3014 Tuesday 1340h

Carbon Cycling in Northern Soils and Surface Waters I *(joint with H)*

Presiding: **J J Carrasco,** U.S. Geological Survey; **R G Striegl,** U.S. Geological Survey; **K P Wickland,** U.S. Geological Survey

B22B-01 1345h INVITED

Progress and Challenges in Modeling Soil Carbon Dynamics of High Latitude Ecosystems: Temporal and Spatial Perspectives

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Much progress has been made in modeling the role of soil carbon dynamics in high latitude ecosystems in response to temporal and spatial variation in climate and disturbance. Temporal variation in climate affects soil carbon dynamics at seasonal to millennial temporal scales. At seasonal time scales, progress has been achieved by representing soil thermal dynamics of high latitude ecosystems including the insulating effects of snow in the cold season and the freeze-thaw dynamics of permafrost soils. At inter-annual time scales, some studies indicate that cooling of the Northern Hemisphere after the Pinatubo Eruption affected the atmospheric growth rate of carbon dioxide through the effects of cooling on decomposition. At decadal and longer time scales, responses of decomposition to climate variability largely depend on how fast vs. slow pools are represented in models. Modeling studies and emerging data from field studies of temporal variation in decomposition after disturbance indicate that decomposition is largely controlled by the amount of remaining substrate and inputs to the soil rather than changes in soil environmental conditions after disturbance. Across high latitude ecosystems, both climate and disturbance appear to interact to influence latitudinal patterns of soil carbon storage. Also, glaciation and soil drainage substantially influence soil carbon storage through interactions with permafrost. While there has been much recent progress in representing how soil thermal dynamics influence soil carbon dynamics, the representation of disturbance regimes, glacial history, and soil drainage in a spatial context presents substantial challenges to modeling spatial variation in soil carbon storage. Modeling the lateral transport and processing of carbon in high latitude soils and surface waters has only recently received attention.

B22B-02 1410h

Methane Emissions from the Terrestrial Ecosystems of Northern High Latitudes during the 20th Century: A Retrospective Analysis with a Process-based Biogeochemistry Model

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Terrestrial ecosystems in high latitudes are predicted to experience more dramatic environmental changes from global warming compared with lower latitude ecosystems. The expected changes include lengthening of the growing season and melting of permafrost, both of which have implications for the methane (CH4) exchanges between terrestrial ecosystems and the atmosphere. To date, most models of large-scale methane dynamics have ignored key aspects of the water and soil thermal regimes in high latitudes that control the timing and magnitude of CH4 exchanges between the land and the atmosphere. Extant methane models have not been coupled with well-validated terrestrial ecosystem models, and so the methane models do not simulate the important links among plant productivity, the availability of labile carbon compounds to microorganisms, and CH4 emissions. In this study we have modified our biogeochemistry model, the Terrestrial Ecosystem Model (TEM 5.0), to include the processes of methanogenesis and methanotrophy in areas with and without permafrost. We enhanced TEM's hydrological module to better simulate soil water dynamics including water table fluctuations. We applied our model to the terrestrial ecosystems at northern high latitudes (45oN above) to evaluate the responses of CH4 emissions to the climate change during the 20th century. Our simulations indicated current CH4 emissions to the atmosphere are about 96 Tg yr-1 from natural ecosystems at northern high latitudes, while methane consumption by soil microbes is about 36 Tg yr-1. Therefore, we estimate that this region is a net source of about 60 Tg CH4 yr-1. The simulations showed there is strong interannual variability in CH4 fluxes and a trend of increasing net CH4 emissions with a rate of 0.06 Tg CH4 yr-1 during the 20th Century. If this increase continues, it will create a strong positive feedback to the climate system.

B22B-03 1425h

Changing sources of respired CO2 with time since fire in a boreal forests

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We compared the carbon isotopic composition of soil CO2 fluxes and potential respiration sources (root and microbial) of 6 forest stands along a chronosequence ranging from 0 to 150 years following stand replacing fire. Study sites are located in the BOREAS Northern Study Area near Thompson, Manitoba, Canada (55N, 98W). The vegetation is dominated by black spruce (Picea mariana), the understorey by mosses. The clay soils have underlying permafrost below 50 to 90 cm. Soil CO2 flux and its carbon isotopic composition was measured using dynamic chambers. Heterotrophic and autotrophic respiration were characterized using in situ and laboratory incubations. Results from a preliminary study in 2001 showed an increasing contribution of heterotrophic respiration with time since fire. Drier conditions in 2003 were associated with dramatically lower CO2 fluxes. We will present isotope data collected in the summer of 2003 and contrast it with our earlier

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study. In addition to surface fluxes we measured CO2 concentration and isotopic signature of depth profiles along the chronosequence. Radiocarbon signatures in the mineral soil differed significantly from the isotopic signature of surface CO2 fluxes, indicating that the majority of the soil respiration flux is derived from near surface layers.

B22B-04 1440h

Dependency of Ecosystem Respiration in a Cool Temperate Bog on Peat Temperature and Water Table

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We measured ecosystem respiration (ER) from nighttime net ecosystem exchange of carbon dioxide determined from an eddy covariance tower located in a large ombrotrophic bog near Ottawa, Canada. Measurements were made from May to October over 5 years, 1998 to 2002. Ecosystem respiration ranged from <0.05 mg CO2/m2/s in spring (May) and late fall (late October) to 0.10-0.15 mg CO2/m2/s during the summer (July-August). As anticipated, there was a strong relationship between ER and peat temperatures, such as at a depth of 5 cm (r2 = 0.63). Q10 over 5° to 15°C varied from 2.2 to 4.2 depending upon the choice of temperature level and location within a hummock or hollow. Unexpected for a wetland ecosystem, there was only a weak relationship between ER and water table position (r2 = 0.11). Comparison of ER in early and late summer, 2002 with similar surface temperature revealed no significant difference in ER. A laboratory incubation of peat cores at different moisture contents showed that CO2 production was reduced by drying in the surface samples, but there was little decrease in samples from below a depth of 30 cm. We believe that the lack of correlation between ER and water table position in this ecosystem results from an increase in CO2 production at depth compensating a decrease in production of CO2 by heterotrophic respiration in the near surface layers and autotrophic respiration in the moss community.

B22B-05 1455h

Physical Evidence for Deep Ebullition Fluxes in Northern Peatlands

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Recent field studies from northern Minnesota indicate that deep ebullition fluxes may be a major component of the methane cycle in large peat basins. Zones of overpressure were discovered under raised bogs across the Glacial Lake Agassiz peatlands in which biogenic gas bubbles accumulate in semi-elastic compartments confined by dense wood layers. Instrument stations at the Red Lake bog indicate that overpressures persist for long periods, although short depressuring cycles are triggered by a combination of droughts and/or sharp declines in atmospheric pressure. These depressuring cycles occur synchronously with large surface deformations that exceed 20-30 cm in 2 to 6 hours indicating the release of large volumes of gas from deep overpressured compartments. We calculate that the 3 largest surface deformations in August 1997 alone were associated with the release of 136 g CH4 m-2 which exceeds by an order of magnitude the annual average chamber fluxes measured at this same site. Similar large changes in gas volume at depth were obtained using 2 different independent methods based on 1) the degree of overpressuring in the deeper peat and 2) relating the barometric efficiency of the piezometers to specific yield of the shallow peat. Further evidence for large volumes of gas in the deeper peat was also detected by imaging peat cores with Magnetic Resonance Imaging. These studies indicate that the dynamics of free-phase gas plays an important role in the carbon cycle of large peatlands.

B22B-06 1510h

The significance of methane ebullition

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Ebullition is often the dominant pathway of methane release from aquatic ecosystems, yet it has seldom been carefully measured, due to heterogeneity in the spatial distribution and episodic release of gas bubbles. This likely results in an underestimation of total methane emission. We took advantage of ice formation over lake surfaces in NE Siberia to map patterns of ebullition. As ice forms in autumn, bubbles released from lake sediments are continually trapped under the ice at the water surface resulting in stacks of bubbles separated by thin films of ice called koshkas'. Mapping the distribution of koshkas enabled us to identify background' patterns of ebullition. In addition, we located hot-spot' ebullition sites that remain permanently open throughout winter due to exceptionally high rates of methane bubbling. We used random and selective placement of underwater/ under-ice chambers to measure background' and hot-spot' fluxes annually. The combination of mapping and chamber measurements among different types of lakes and along lake margins varying in intensity of thermokarst erosion or aquatic plant growth enabled us to 1) improve estimates of total methane emissions from NE Siberian lakes, and to 2) identify landscape processes (thermokarst erosion vs. wetland mat formation) that enhance methane production and emission. Ignoring the contribution from hotspots, background ebullition comprised more than 75% of total methane emissions from lakes. From hotspot sites we measured up to 10-L m-2 of methane per day in early summer. Although hotspots comprised roughly 0.05% of the area along thermokarst margins, where they were most common, ebullition from hotspots contributed approximately 69% of the total ebullition flux. Including the flux from hotspots could increase estimates of CH4 ebullition from thermokarst margins 300%! Thermokarst lakes in Russia comprise a large proportion of the world's high latitude lakes; yet they are understudied. North Siberian lakes differ from most lakes in Alaska and Canada because they are surrounded by ice-rich (50-90% ice) permafrost that facilitates intense thermokarst erosion along lake margins. In turn, organic-rich (2%) mineral soil subsides into anaerobic lake bottoms, providing a fresh, labile substrate for methanogenesis. Increased thermokarst erosion with climate warming would provide a positive feedback to methane production and emission from lakes. Although thermokarst activity likely results in higher emissions of methane via ebullition from North Siberian lakes than from other northern lakes, results from this study suggest ebullition may be a more important pathway of methane emission than what has been reported to date.

B22B-07 1525h

Use of Stable Isotopes and Incubation Studies to Characterize Methane Production Mechanism in Northern Wetlands

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Arctic and boreal ecosystems are important since they occupy greater than 1/5 of the Earth's terrestrial surface, they are sensitive to subtle climate changes, and they have significant effects on the atmosphere. Methanogenesis is dominated by two major pathways, acetotrophic (i.e., acetoclastic) methanogenesis in which acetate is the immediate precursor of CH4 (and CO2), and H2/CO2 methanogenesis in which CH4 is a product of H2 oxidation coupled with CO2 reduction. Recent studies suggest that acetotrophic methanogenesis does not occur widely in the northern wetlands and acetate can accumulate to high levels (Duddleston et al., 2002; Hines et al., 2001a). Methanogenesis at these sites is dominated by the H2/CO2 pathway and the importance of acetate as a precursor of CH4 seems to decrease with decreasing temperature and increasing oligotrophy. We surveyed a transect across Alaska from Deadhorse to Anchorage and used stable isotope distributions of DIC, CH4 and H2O to discern the relative importance of differing methane production mechanisms. These results compared favorably to incubation studies. Vegetation type was found to be a strong indicator of methane production mechanism, with Carex indicating acetotrophic methaneogenesis and sphagnum being an indicator of a lack of acetate methaneogenesis. The effects of production pathway variation on the dD of methane will also be presented.

B22C MCC: 3002 Tuesday 1340h

Validation and Application of Land Surface Products From the MODIS Sensor II *(joint with H, GC)*

Presiding: **S W Running,** University of Montana**; R Nemani,** NASA Ames Research Center

B22C-01 1345h

Terrestrial Carbon Sinks Predicted From MODIS Satellite Data and Ecosystem Modeling

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A simulation model (NASA-CASA) based on satellite observations of monthly vegetation cover from the moderate resolution imaging spectroradiometer (MODIS) was used to estimate monthly carbon fluxes in terrestrial ecosystems during 2001. For the terrestrial biosphere, predicted net ecosystem production (NEP) flux for atmospheric carbon dioxide was estimated as annual net sink of 3.6 Pg C. Our NASA-CASA model results for NEP in 2001 reflect observed climate patterns between and within major continental areas of the terrestrial biosphere. Above average temperatures were strongly associated with positive NEP (net sink fluxes) across the high latitude zones of eastern Canada and Eurasia. Positive NEP fluxes were also associated with the heavy rainfall reported in eastern Europe, Siberia, Australia, West Africa, and southern Africa. Negative NEP (net source fluxes) were associated with severe droughts reported in south Asia, eastern Africa, northern China, and northern and eastern coastal South America.

URL: http://geo.arc.nasa.gov/sge/casa/