Mean daily over-winter CO2 fluxes were significantly related to soil carbon content at the landscape scale. Similarly, labile carbon additions to soil increased subnivian CO2 fluxes 25 to 80 percent after 24 hours and 76 to 85 percent after 30 days. Although fluxes remained elevated 30 days following carbon addition, isotopic analyses indicated that the source of the respired carbon was soil organic matter and not added carbon. The magnitude of the increase in CO2 fluxes, coupled with increased utilization of endogenous organic matter, suggest that increases in labile carbon availability from litter may prime heterotrophic mineralization of stored soil organic matter.

C42A MCC: Level 2 Thursday 1330h

Snow Cover and Biogeochemical Cycling II Posters *(joint with B, H)*

Presiding: **M Sturm,** Cold Regions Research and Engineering Laboratory Alaska**; P D Brooks,** University of Arizona

C42A-1005 1330h POSTER

Contrasting Responses of Arctic Tussock Tundra to Early Season Snow Melt: Growth Acceleration Versus Frost Damage

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Climate warming scenarios for the Arctic include early snow melt marking the beginning of the growing season. From the perspective of the vegetation, early snow melt may have advantageous or disadvantageous effects. With warm weather following snow melt, bud break and flowering will occur early providing a longer period for growth and photosynthesis. However, if very cold weather follows snowmelt, plants will be exposed directly to freezing conditions that plants under the snow would not. Such exposed plants may suffer freeze damage and delayed bud break. We have been experimentally manipulating snow cover at Toolik Lake, Alaska, since 1995. In 9 years of early snow removal treatments, in only two years has the second scenario occurred, in 2001 and 2002. Here we document the effects of very cold conditions following snow removal on green biomass as assessed by NDVI of treatment plots relative to controls. In 2001 evergreens shrubs were killed, bud break was delayed, and NDVI was lower on treatment plots relative to controls. In contrast, in a year with warm spring temperatures following snow melt, 1999, NDVI on treatment plots was significantly greater than that of controls. Cold conditions following snow melt may lead to death of shrubs and delayed budbreak, effects that will carry over throughout the growing season and ultimately, affect community composition and ecosystem function.

C42A-1006 1330h POSTER

Flowpath Transformations of Precipitation Chemistry in an Arctic Tundra Catchment

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This paper traces the drainage pathways followed by rainfall and snowmelt in an actic tundra basin. The major hydrological processes operating within each flowpath segment from the surface of melting snow to the basin outlet are related to changes in the ion chemistry of the water flowing from each segment. In so doing, this paper offers physically-based explanations for the transformation of major ion concentrations and loads of snowmelt water as it travels to the stream outlet in this environment. Despite representing only five percent of the basin water equivalent, snow drifts were found to control the ion chemistry of the water in hillslope flowpaths and in the stream channel. As the initial pulse of ion-rich meltwater was conveyed through hillslope flowpaths, the concentrations of most ions increased, and the duration of peak ionic pulse lengthened. The hillslope runoff process also replaced Na+ and Cl-, the major ions in the percolate with Ca2+ and Mg2+. Over the first three metres of surface flow, concentrations of most ions increased by one to two orders of magnitude, which was roughly equivalent to the concentration increase that resulted from percolation of relatively dilute water through 0.25 m of unsaturated soil. On slopes below a large melting snowdrift, ion concentrations of meltwater flowing in the saturated layer of the soil were very similar to the relatively dilute concentrations found in surface runoff. However, once the snowdrift ablated, sub-surface flow ion concentrations rose steadily above parent meltwater concentrations. Water chemistry in the stream channel strongly resembled that of drainage from adjacent hillslopes. In-channel geochemical processes increased the concentration of most ions with flow distance in the major channel.

C42A-1007 1330h POSTER

Shrub Height and Snow Depth In The Alaskan Arctic

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Deciduous shrubs are predicted to increase in size and abundance in arctic tundra with climate warming. However, one barrier to this increase in shrubs may be exposure of taller stems above the snow pack where winter damage from dessication, abrasion, cold and browsing can occur. We measured shrub height and snow depth along transects at several sites from Atquasuk (70.5 N 157.5 W) and Oumalik north of the Colville River to sites south of the Colville River (Ivotuk) and in the Seward Peninsula (64.9 N 163.7W). We found that, although summer shrub heights are often greater than snow depths, these shrubs are usually snow covered by the Deep Cold stage of winter. One or a combination of two mechanisms account for this:1) 'lay over' of stems pushed over by wind or snow load and 2) buildup of snow around and over shrubs by the trapping of blowing snow by a dense network of branches and shoots. As deciduous shrubs become taller in response to climate warming, these mechanisms may allow them to remain protected in the winter despite an even greater mismatch in shrub height and snow depth.

C42A-1008 1330h POSTER

The Impact of Snow-up Timing on Arctic Winter Soil Temperatures

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For ecosystems that are snow-covered during a significant part of the year, variations in the nature and timing of snow pack development can produce large year-to-year differences in the thermal regime of the soil. Here we use continuous snow-ground interface temperature measurements from two consecutive winters taken across a variety of vegetation types on the Seward Peninsula, Alaska, to quantify these differences. The first winter (2000-2001) had an above-average snow pack that was largely in place by November. The second winter had a below-average snow pack that did not develop until January. Interface temperatures the second winter averaged 10 to 20°C lower than the first despite similar air temperature regimes. Moreover, distinct differences in soil thermal regime that developed as a function of different vegetation types the first winter were largely absent in the second. The measurements also show that with increasing canopy height and stem diameter, the thermal regime of the soil is spatially more heterogeneous. The results suggest that larger changes in winter soil thermal regime can be induced through changes in the timing of the development of the winter snow pack than can be induced through step changes in winter air temperature.

C42A-1009 1330h POSTER

Snow removal and ambient air temperature effects on forest soil temperatures in northern Vermont

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We measured deciduous forest soil temperatures under control (unmanipulated) and snow-free (where snow is manually removed) conditions for four winters (at three soil depths) to determine effects of a snow cover reduction such as may occur as a result of climate change on Vermont forest soils. The four winters we studied were characterized as:cold and snowy', warm with low snow', cold with low snow', and cool with low snow'. Snow-free soils were colder than controls at 5 and 15 cm depth for all years, and at all depths in the two cold winters. Soil thermal variability generally decreased with both increased snow cover and soil depth. The effect of snow cover on soil freeze-thaw events was highly dependent on both the depth of snow and the soil temperature. Snow kept the soil warm and reduced soil temperature variability, but often this caused soil to remain near 0 deg C, resulting in more freeze-thaw events under snow at one or more soil depths. During the cold snowy' winter, soils under snow had daily averages consistently > 0 deg C, whereas snow-free soil temperatures commonly dropped below -3 deg C. During the warm' year, temperatures of soil under snow were often lower than those of snow-free soils. The warmer winter resulted in less snow cover to insulate soil from freezing in the biologically active top 30 cm. The possible consequences of increased soil freezing include more root mortality and nutrient loss which would potentially alter ecosystem dynamics, decrease productivity of some tree species, and increase sugar maple mortality in northern hardwood forests.

C

C42A-1010 1330h POSTER

Trace Metal Concentrations in Snow From the Yukon River Basin, Alaska and Canada.

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We report here on metal concentrations in snow collected from the Yukon River basin. Atmospheric transport of metals and subsequent deposition is a known mechanism for introducing metals into the northern environment. Potential sources of airborne elements are locally generated terrestrial sources, locally derived anthropogenic sources, and long range atmospheric transport. Sites were distributed along the Yukon River corridor and within the southeastern, central, and western basin areas. Snow samples were taken in the spring of 2001 and 2002 when the snow pack was at its maximum. Composite samples were taken from pits using clean techniques. Mercury was analyzed using cold vapor atomic fluorescence spectrometry. All other elements were analyzed by inductively coupled plasma-mass spectrometry. In samples from remote sites, the concentration for selected metals ranged from: 0.015 - 0.34 ug/L for V, 0.01 - 0.22 ug/L for Ni, <0.05 - 0.52 ug/L for Cu, 0.14 - 2.8 ug/L for Zn, 0.002 - 0.046 ug/L for Cd, 0.03 - 0.13 ug/L for Pb, 0.00041 - 0.0023 ug/L for filtered-Hg. Because the entire snow pack was sampled and there was no evidence of mid-season thaw, these concentrations represent the seasonal deposition. There was no significant difference in the seasonal deposition of V, Ni, Cu, Zn, Cd, and Pb at these sites between 2001 and 2002, and no north-south or east-west trend in concentrations. Samples taken from within communities, however, had significantly higher concentrations of V, Ni, Cu, Zn, and Cd in 2001, and Ni, Cu, and Pb in 2002 relative to the remote sites. Our data indicate that the atmospheric deposition of metals in the Yukon River basin is relatively uniform both spatially and temporally. However, communities have a measurable but variable effect on metal concentrations.

C42A-1011 1330h POSTER

Soil nitrogen dynamics during seasonal transitions: N retention and loss in ecosystems of the Sierra Nevada, California

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The maintenance of nitrogen (N) limitation in many terrestrial ecosystems may be mediated by N losses that occur during seasonal transitions. In the southern Sierra Nevada, short-duration nitrate pulses associated with spring snowmelt in the alpine, and with fall rains at lower elevations, may account for greater than 90% of annual DIN export. To evaluate the role of microbial processes in mediating such losses of N, we examined overwinter variation in soil N dynamics at a high (2800 m) and low (750 m) elevation site. The fall transition marked a period of intense nitrifier activity at both sites: field incubations showed five-fold to 30-fold increases in soil NO_3^- pools with the onset of fall freeze-thaw and rewetting events, followed by 60%-75% decreases in total soil inorganic N and net N mineralization rates. Nitrogen held in microbial biomass decreased significantly at the alpine site but recovered to growing-season levels under snowpack, indicating biotic sequestration of N. With the onset of spring snowmelt, microbial biomass again decreased, producing an increase in soil inorganic N concentrations and a shift from net N_2O consumption to production. These results, paired with results of laboratory incubations, indicate that physical disturbances incurred during seasonal transitions may enhance nitrification and gaseous losses from soil, and that large fluctuations in microbial biomass may regulate N production and export in these systems.

C42A-1012 1330h POSTER

Nitrogen Dynamics Along the Western Slope of the Sierra Nevada, California

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Along the western slope of the Sierra Nevada, elevation ranges from 200 to 4000 meters over a distance of less than 25 km. Biomes along this gradient range from chaparral, through mixed conifer and Giant Sequoia forests to alpine fell fields. Rates and forms of N loss from these biomes vary considerably. In middle elevation oak and mixed conifer forests, dissolved organic nitrogen (DON) is the dominant form of N in catchment outflow (>95%) and, on an annual basis, is less than or about equal to inorganic N loading (DIN)(ca. 4 kg/ha/yr). In catchments near the elevation extremes, DIN export is significant and, when combined with DON losses, catchment N-losses balance or can exceed inorganic N loading. DIN export from Sierra Nevada catchments is generally confined to hydrologic flushing periods during seasonal transitions (e.g., transitions from dry summers to fall rains, and from winter to spring snowmelt). In alpine catchments nitrate pulses typically range from 5-20 uEq/L, while in middle elevation catchments nitrate levels are less than 1 uEq/L. Nitrate concentrations during first flush storms in chaparral catchments can exceed 500 uEq/L and may be related to elevated dry deposition of N (10 kg/ha/yr). These observations suggest: (1) forested ecosystems in the Sierra Nevada are generally more N-retentive than alpine or chaparral systems (2) ecosystems at elevational extremes are less N-retentive and may be more sensitive to changes in N deposition rates and 3) abrupt seasonal transitions may be a common mechanism controlling nitrate losses in alpine and chaparral ecosystems.

C42A-1013 1330h POSTER

Use of fluorescence spectroscopy to detect the seasonal change in the redox state of dissolved organic matter in Nymph Lake, Rocky Mountain National Park, CO

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Fluorescence spectroscopy was used to examine the redox state and chemical character of dissolved organic matter (DOM) in Nymph Lake, a seasonally ice-covered lake in Rocky Mountain National Park, CO. Water samples were collected monthly beneath the ice from December through April during the 2002/2003 winter and spring seasons. A sample was also collected in June when the lake was ice free and well mixed. Excitation-Emission Matrices (EEMs) of filtered, whole water samples shifted in a manner consistent with laboratory reduced fulvic acid (Klapper et al. 2002) as the winter season progressed. The EEMs from December through March showed a pattern of decreasing intensity and disappearance of the two peaks in region A and C (peaks labeled according to Coble et al. 1990). The April EEM showed an increase in intensity and reappearance of the two peaks, suggesting some oxidation had occurred. The two peaks in region A and C had the highest intensities in the June EEM, suggesting further oxidation and/or input of oxidized DOM during snowmelt. Titration with ferric citrate of the reduced March and partially reduced April samples resulted in an increase of ferrous iron concentration proportional to the amount of ferric iron added. Furthermore, titration with ferric citrate caused a shift in the March and April EEMs; peaks in regions A and C reappeared in the March sample and the intensities of those peaks were increased in the April sample. An increase in ferrous iron concentration with a simultaneous shift in the EEMs upon addition of ferric iron provide compelling evidence that redox-active moieties of DOM serve as electron shuttles for microbially mediated ferric iron reduction under the ice in Nymph Lake. Trends in dissolved oxygen, ferrous and ferric iron concentration, and Eh potential under the ice provided additional evidence for microbially mediated reduction of Nymph Lake DOM. Lastly, the EEMs from this study clearly show that the redox-active moieties of DOM, quinones (Scott et al. 1998), are largely responsible for the fluorescent character of Nymph Lake DOM, and likely contribute to the fluorescence of DOM from many environments.

C42A-1014 1330h POSTER

Seasonal variation of a snow algal community on an Alaskan glacier

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There are cold tolerant algae (snow algae) growing on the surface of glaciers. Several species of snow algae have been reported on Alaskan glaciers. Seasonal variation of the snow algal community was investigated on Gulkana Glacier in the Alaska Range from May to September, 2001. Chlorophyll, nutrients, and stable isotope for carbon and nitrogen (particulate organic matter) were also measured. The snow algal community on this glacier varied with time, in particular changed with snow melting and nutrients in the snow. When the glacier is covered with snow (May), the algal community consisted of mainly only one species of alga (Chlamydomonas nivalis, alga of red snow). The algal biomass and chlorophyll concentration increased with snow melting in early summer. When the glacial ice surface appeared, the community structure changed drastically. The community on the ice consisted of some of different species. The community structure and biomass kept almost constant after the ice surface appeared. Nutrients measurements showed that nitrogen was likely limited on the algal growth rather than phosphate. Especially, the nitrate was depleted from August to September. Results of stable isotope measurements also support the nitrogen limitation of the snow algae in late summer.

C42A-1015 1330h POSTER

Global Mercury Pathways in the Arctic Ecosystem

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The sudden depletions of atmospheric mercury which occur during the Arctic spring are believed to involve oxidation of gaseous elemental mercury, Hg(0), rendering it less volatile and more soluble. The Hg(II) oxidation product(s) are more susceptible to deposition, consistent with the observation of dramatic increases in snow mercury levels during depletion events. Temporal correlations with ozone depletion events and the proliferation of BrO radicals support the hypothesis that oxidation of Hg(0) occurs in the gas phase and results in its conversion to RGM (Reactive Gaseous Mercury). The mechanisms of Hg(0) oxidation and particularly Hg(II) reduction are as yet unproven. In order to evaluate the feasibility of proposed chemical processes involving mercury in the Arctic atmosphere and its pathway after deposition on the snow from the air, we investigated mercury speciation in air and snow pack at Resolute, Nunavut, Canada (latitude 75°N) prior to and during snow melt during spring 2003. Quantitative, real-time information on emission, air transport and deposition were combined with experimental studies of the distribution and concentrations of different mercury species, methyl mercury, anions, total organic carbon and total inorganic carbon in snow samples. The effect of solar radiation and photoreductants on mercury in snow samples was also investigated. In this work, we quantify mercury removed from the air, and deposited on the snow and the transformation to inorganic and methyl mercury.

C42A-1016 1330h POSTER

Photolysis of Nitrate and Nitrite in Artificial Snow and Artificial Ice

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It is well known that nitrate and nitrite undergo photolysis in aqueous solution. Recent studies show that these reactions are likely to occur in natural snow as well. Therefore it is of interest to measure rates of photolysis of nitrate and nitrite in snow and ice. In this study artificial snow was made by spraying a solution onto the wall of a reservoir containing liquid nitrogen. Artificial snow and ice were irradiated in a sealed quartz tube with a UV lamp and production of hydroxyl radicals was quantified. Hydroxyl radicals produced in these processes react with dimethyl sulfoxide to release methyl radicals, which were trapped by 3-amino-2,2,5,5-tetramethyl-1-pyrrolidinyloxy free radical (3AP). The 3AP-CH_3 compound was later derivatized to produce a highly fluorescent adduct, which was measured by HPLC. Snow produced the highest yield of hydroxyl radicals and ice the lowest. Nitrite had higher yield than nitrate. The calculation of photolysis rates for nitrate and nitrite in snow and ice is discussed.

C42B MCC: 3002 Thursday 1340h

CLPX: Cold Lands Processes Field Experiment I *(joint with H)*

Presiding: **D Cline,** NOAA National Operational Hydrologic Remote Sensing Center**; K Elder,** Rocky Mountain Research Station, U.S. Forest Service

C42B-01 1345h

An Overview of the Data Collected During the Cold Land Processes Field Experiment

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