B31B-04 0845h INVITED

Trace Gas Emissions in Temperate Forests and Impact of Forest Conversion

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Temperate forest ecosystems play a significant role as sources and sinks for primarily and secondarily active trace gases such as N2O, NO and CH4. In recent decades the magnitude of the biosphere-atmosphere exchange of these trace gases has been substantially altered due to direct and indirect anthropogenic activities. E.g. measurements at different forest sites across Europe exposed to different loads of atmospheric N-deposition clearly show, that N-oxides emissions are positively correlated to N-deposition, whereas CH4 uptake rates are negatively affected. Furthermore, stand properties such as tree species composition as well as stand age have also been demonstrated to strongly affect the exchange of these trace gases. Results of continuous measurements of N-oxide emissions at the Höglwald Forest site, Germany, show that e.g. NO-emissions from a spruce site are approx. 6 fold higher (5-7 kg NO-N ha-1 yr-1) than N2O emissions (0.5-1 kg N2O-N ha-1 yr-1), whereas at an adjacent beech site -stocking on a comparable soil- N2O-emissions are 3-5 kg N2O-N ha-1 yr-1 and NO emissions are 2-2.5 kg NO-N ha-1 yr-1. These results are further supported by microbiological process studies, which show that the forest type can alter the magnitude of the key microbial processes mineralization and nitrification by its effect on soil moisture conditions and substrate quality. However, estimates of trace gas exchange between temperate forest soils and the atmosphere remain fragmentary if the effect of direct anthropogenic management activities such as clear cutting and reforestation are neglected. Therefore, in 1999 we started a multi-year experiment at the Höglwald Forest, Bavaria, in which we investigated the effect of the conversion of a spruce forest into a beech forest either by clear cutting or selected cutting on N2O, NO and CH4 emission/deposition. The results of this study show, that clear cutting strongly enhanced N2O emissions from approx. 0.5 kg N2O-N ha-1 yr-1 to $>$ 5 kg N2O-N ha-1 yr-1 not only for one year but for several consecutive years, whereas NO emissions remained at an high level in the year after clear cutting ($>$ 5 kg NO-N ha-1 yr-1), but declined thereafter. CH4 uptake decreased sharply after clear cutting to values close to zero and did not recover even 4 years after site management. If our results are extrapolated for a typical rotation span of a plantation (80-100 years), it becomes evident that increased rates of N2O losses and reduced rates of CH4 uptake within the first decades of forest conversion will reduce the net greenhouse gas balance of forests -including the net ecosystem exchange of CO2- by up to 35 percent. Compared to these dramatic effects, selected cutting exhibited only in the first year significant effects on exchange rates of N2O-, NO- and CH4, thus, indicating that this forest management practice is more sustainable with regard to the protection of the atmosphere.

B31B-05 0900h INVITED

Land Use Change Effects on Nitrous Oxide Emissions in Tropical Regions

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Soil emissions of nitrous oxide (N_2O) are the single most important natural source for this gas and also the single largest anthropogenic contribution to the global budget of N_2O. The availability of oxygen, inorganic nitrogen, and organic carbon are the three principle limitations to soil emissions of N_2O. These limitations play the same roles in soils globally, so there is nothing intrinsically different about processes in the tropical regions versus the temperate and boreal zones. However, the tropical regions are a far more important natural source of soil derived N_2O and will increase greatly in importance for anthropogenic emissions in the future. Both the area dedicated to agriculture and the quantity of nitrogenous fertilizer applied are relatively stable in the temperate zone while they are increasing rapidly in the tropical zone. When considering N_2O emissions, there are two important eco-regions in the tropics, savannas and forests. In both of these regions, natural ecosystems are being converted to pasture lands and to intensive agriculture. N_2O emissions from natural savannas are minimal. Conversion to pasture and to agriculture has limited effects. In savanna systems the natural limitation of nitrogen and the abundance of oxygen combine to minimize N_2O emissions from soils. In the forested regions, the situation is different. Tropical forests, particularly in humid areas, are nitrogen rich. Conversion of forests to pastures may lead to a brief pulse (from a few months to a decade) of elevated nitrous oxide emissions. Unless pastures are fertilized, their emissions are generally far below native forest emissions of N_2O. Where N fertilizer use is heavy, conversion of forests (or pastures) to agriculture may lead to significant increases in N_2O emissions. But under extensive management or careful intensive management, it is possible for agricultural systems in the humid tropics to have lower N_2O emissions than native ecosystems.

B31B-06 0915h INVITED

Trace Gas and Carbon Sequestration Dynamics in Temperate Croplands and Successional Ecosystems: A Full-Cost Accounting

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Agriculture is responsible for 21-25% of the global anthropic CO2 flux, 55-60% of the anthropic CH4 flux, and 65-80% of the anthopic flux of N2O. A number of CO2 stabilization strategies target agricultural production practices, and the potential for simultaneously abating fluxes of the non-CO2 greenhouse gases is substantial. But so is the potential for creating greenhouse gas (GHG) liabilities, the unintentional increase in one or more GHGs by activities that mitigate another. Whole-system accounting provides a means for including all GHG-contributing processes in the same cropping system analysis in order to illuminate major liabilities and synergies. We contrast a field crop system in the upper U.S. midwest with unmanaged successional ecosystems in the same landscape, and provide evidence that N2O flux - the major contributor to radiative forcing in row-crop systems - can be abated with little loss of crop productivity.

B31B-07 0930h INVITED

DAYCENT Model Assessment of Land Use Change and Management on C and N Fluxes in the USA Great Plains

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Land use changes have dramatically altered the biogeochemical cycling associated with greenhouse gas (GHG) fluxes. During the past 100+ years approximately 60% of the Great Plains grasslands have been converted to crop production. This has resulted in increased N_2O emissions, decreased CH_4 uptake, and depletion of soil organic matter (SOM). However, appropriate use of land management can reduce GHG gas emissions from agricultural systems while maintaining or increasing crop yields. In recent years improved management systems have been introduced which conserve and enhance SOM. The DAYCENT ecosystem model was used to compare the effects of converting Great Plains grasslands to crop production and the effects of different management on net GHG fluxes (GHG_{net}) and crop yields for agricultural systems in the Great Plains of the USA. Improved management includes conversion from intensive tillage to no-till cultivation, and reduction of summer fallow periods by replacing continuous winter wheat cropping with alternative rotations that are economically viable for different climate regimes within the Great Plains. Changes in soil organic carbon, N_2O emissions, CH_4 uptake, CO_2 fluxes, and the CO_2 costs of N fertilizer production were converted to a common unit of CO_2-C equivalents and summed to obtain GHG_{net}. At the regional level, grassland systems are neutral or small GHG_{net} sinks, dryland agriculture is a source, irrigated agriculture is a minor sink, and improved management is a major sink.

B31B-08 0945h INVITED

A Science Plan for Integrated Studies of Coupled Biosphere-Atmosphere Carbon and Nitrogen Cycles

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Human activities, such as the burning of fossil fuels and the use of nitrogen fertilizers, have approximately doubled levels of reactive nitrogen in the biosphere. This perturbation has the potential to alter fundamental processes in terrestrial ecosystems where composition, diversity, and productivity are largely controlled by the availability of nitrogen. A variety of theoretical and experimental studies indicate that nitrogen inputs have a direct impact on fluxes of carbon into ecosystems controlling both CO2 assimilation and the exchange of carbon-based trace gases. In some systems, plant growth and carbon storage appear to be enhanced by nitrogen addition. In contrast, other systems exhibit stagnant or declining plant growth with nitrogen addition as the ecosystem becomes N-saturated and susceptible to stressors such as soil acidification and ozone damage. The magnitudes of the nitrogen and carbon responses appear to depend directly on the pathway and magnitude of nitrogen flux into ecosystems. However, the pathway of nitrogen entry into ecosystems, the chemical species of that nitrogen and its level of incorporation into plant and soil biomass pools are poorly understood in many, if not all, ecosystems. A workshop was held in Boulder, Colorado, in November 2003 to develop a science plan to address the critical need to integrate leaf-level plant physiology, ecosystem, and atmospheric chemistry perspectives to determine the fate of nitrogen and thus carbon in terrestrial systems. Participants brought expertise in plant physiological ecology, biochemistry, soil microbiology, biogeochemistry, atmospheric chemistry, biosphere/atmosphere fluxes, and integrated modeling. On behalf of all participants, we present here the prioritized results of the workshop; including gaps in understanding, technological challenges of integrating biological, ecosystem and atmospheric compartments of carbon and nitrogen cycling, feedbacks in carbon and nitrogen cycle coupling that are likely to produce non-linear responses in the earth system, and identified resource needs for near-term research aimed at reducing uncertainties.

B31C MCC: Level 1 Wednesday 0830h

Carbon Cycling in Northern Soils and Surface Waters III Posters *(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

B31C-0301 0830h POSTER

Rhizosphere C flux from tree roots to soil: spatial and temporal differences between sugar maple and yellow birch saplings

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Rhizosphere carbon flux (RCF) has rarely been measured for intact root-soil systems. We measured RCF for eight year-old saplings of sugar maple (Acer saccharum) and yellow birch (Betula allegheniensis) collected from Hubbard Brook Experimental Forest and transplanted into 35 cm diameter pots with native soil horizons intact. We hypothesized birch roots which support ectomycorrhizal fungi would release more C to the rhizosphere than sugar maple roots which support vesicular-arbuscular mycorrhizal fungi. Saplings (n=5) were pulse-labeled with $^{13}CO_2$ at ambient CO_2 concentrations for 4-6 hours, and the label was chased through rhizosphere and bulk soil pools in organic and mineral horizons for 7 days. We observed immediate appearance of the label in rhizosphere soil, and there was a striking difference in the temporal pattern of ^{13}C concentration between species. In maple, peak concentration of the label appeared at day 1 and declined over time whereas in birch the label increased in concentration over the 7 day chase period. As a result, total RCF was 2-3 times greater from birch roots. We estimate at least 5% and 10% of NPP may be released from this flux pathway in sugar maple and yellow birch saplings respectively. These results suggest that rhizosphere C flux likely represents a substantial proportion of NPP in northern hardwood forests, and may be influenced by trees species and mycorrhizal association.

B31C-0302 0830h POSTER

Methane consumption and soil respiration by a birch forest soil in West Siberia

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Methane and carbon dioxide fluxes were measured in a birch forest soil in West Siberia, in August 1999, June 2000, and September 2000. The study site had a very thick organic horizon that was droughty during the observation periods. The soils always took up CH_4, while CO_2 was released from the surface to the atmosphere. CH_4 consumption and CO_2 emission rates ranged from 0.092 to 0.282 mg C m^{-2} h^{-1} and from 114.3 to 397.3 mg C m^{-2} h^{-1}, respectively. The CH_4 consumption rate and soil temperatures showed significant relationships for individual measurements and monthly averages. The soil respiration rate weakly correlated with individual soil temperatures. Average temperatures for several hours prior to the flux measurement had higher correlations with both CH_4 consumption and soil respiration rates than did instantaneous temperature measured at the time of flux measurement, suggesting that soil temperature has a lag effect on both rates. Soil moisture and both fluxes showed no correlations. The limited variation of soil moisture during our observation may account for the lack of correlation. However, droughty soil conditions resulted in high gas diffusion and, consequently, high CH_4 consumption.

B31C-0303 0830h POSTER

Temporal Variability in Growing Season CO_2 Exchange of a High Arctic Ecosystem.

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Within the ZERO (Zackenberg Ecological Research Operations) programme, continuous micrometeorological measurements of CO_2 exchange in a high arctic ecosystem have been conducted during summer seasons in NE Greenland since 2000. In addition to these measurements, there has previous been measured CO_2 from other dominant surfaces in the valley ecosystem. Here we present the results of the measurements carried out during the years 2000-2003 at a high arctic heath site. In addition measurements conducted in 1997 from one other dominant ecosystem is also presented. The study is an intercomparison of Net Ecosystem Exchange (NEE) among the 4 years and the environmental parameters governing the exchange. In Zackenberg NEE shows seasonal as well as inter annual variation, following the seasonal change in the environmental controls. At the heath site NEE ranged from a source of 0,8 gC/m^2day to a sink of -1,1 gC/m^2day in the 4 years of continuous measurements. The measurements show that start and length of the snow-free season is an important variable to explain the inter annual variability. Onset of the growing season is governed by the extent and magnitude of the snow cover in the valley. Once the snow disappears the vegetation start developing and the photosynthesis can take place, turning the C source into a net sink. Maximum CO_2 uptake occurs at the time of maximum leaf area index. The end of the sink season is marked by the photosynthetic uptake of CO_2 being balanced by the respiratory loss of CO_2. The ecosystem turns into a source again by the end of the growing season. The end of the growing season differs only by a few days during the years of measurements at the heath site, whereas the onset of the growing season differs with almost 2 weeks during the 4 years. The results of the NEE illustrate that the magnitude of the fluxes during the growing season differ through the 4 years, which indicate that the heath ecosystem is sensitive to changes in environmental factors. Thus when the growing season starts late, NEE is affected since the growing season ends almost at the same time each year. Leading to the conclusion: late snow melt results in delayed growing season and therefore decreased seasonal CO_2 uptake.

B31C-0304 0830h POSTER

Temperature Effects on Carbon Isotope Composition of Soil-respired Carbon Dioxide: an Incubation Study with arctic Soils

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Climatic conditions in arctic regions have been favorable for carbon sequestration in the geologic and historic past and an estimated 14% of the earth's terrestrial carbon is found in soils of tundra ecosystems. Climatic warming may change (or may have recently changed) tundra ecosystems from a sink to a source of CO_2. Up to now, little information exists on the nature of soil organic matter (SOM) respired and it is unclear so far if only a fraction of the soil carbon (e.g. labile SOM) is temperature-sensitive or if microorganisms are able to utilize more stable, recalcitrant C pools, that dominate the SOM in tundra soils. We conducted a long-term incubation experiment with intact soil cores of a shrub-moss tundra ecosystem at three different temperatures (2, 12 and 24° C) and analyzed the isotopic signature of respired CO_2 to assess which fractions of SOM are available for decomposition at various temperatures. Despite a general increase in respiration rates with increasing temperatures, a substrate limitation of microorganisms occurred at 24° C in mineral horizons, while no substrate limitation was observed in organic horizons. The $\delta^{13}C$ values of CO_2 respired were negatively correlated to temperature, indicating the utilization of SOM fractions that were depleted in ^{13}C at higher temperatures. Chemical fractionation showed that the most easily available substrates for microbial respiration were also most enriched in ^{13}C. Our results therefore demonstrate that microorganisms may be able to mobilize recalcitrant soil carbon pools at elevated temperatures, indicating that a large proportion of tundra SOM is potentially mineralizable. When the $\delta^{13}C$ values of respired CO_2 of soils, which were incubated either at 2°C or 24°C, were measured at 12°C, the isotopic signature, within a few hours, shifted to values normally found at this temperature. This may indicate that certain groups of soil microbes exhibit characteristic temperature optima and preferences for specific C compounds.

B31C-0305 0830h POSTER

The Timing of Spring Thaw and its Impact on Carbon Exchange in a New Hampshire Fen

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Exchange of carbon dioxide (CO_2) in a wetland during the winter/spring transition is traditionally thought of as a combination of an initial abiological pulse due to build up under the snow/ice cover over the winter months and the onset of biological processes controlling CO_2 exchange. Manual sampling during this period will either underestimate or miss these processes. Automated chamber systems allow us to quantify these processes because of their high sampling frequency throughout the thaw period. Net ecosystem exchange (NEE) measurements were made using an automated system of 10 automatic chambers completing a set of measurements every 3 hours at Sallie's Fen in Barrington, NH. Data for 2001, 2002 and 2003 reveal three diverse thaw periods. Depending on the severity of the winter (snow pack versus ice coverage), the ground temperature and the time of maximum photosynthetic ally active radiation (PAR), the thaw varies from day 82 in 2001, day 86 in 2002, and day 101 in 2003. Years 2001 and 2003 showed a very low level of NEE (> - 1.5 mol CO_2 m^{-2} s^{-1}) throughout the winter months. In 2002, NEE was not measurable until the mid February thaw then persisted at the same low level as observed in 2001. The timing and magnitude of the abiological pulse of CO_2 also varies between years. Year 2001 showed a thaw in early February that released a large pulse of CO_2 with subsequent smaller pulses throughout the late winter. Two large pulses on days 53 and 60 coinciding with increased air temperatures were observed in 2002. In 2003 there were smaller pulses dispersed throughout the thaw period. The winter of 2002 was characterized by little snowfall therefore a thick ice pack developed on the surface of the wetland. When the ice melted, the accumulated CO_2 was released in a large pulse. 2003 was characterized by a thick snow pack thereby insulating the peat surface and allowing for more evenly dispersed emission as the snow melted. The variability in the timing of the abiological pulse(s) and the onset of biological exchange of CO_2 is controlled by weather. Increased temperature and a lengthened growing season in Northern latitudes will affect the rate of carbon exchange and the carbon balance of wetland environments.

B31C-0306 0830h POSTER

Soil Respiration in a Black Spruce Forest and Adjacent Thermokarst Wetlands in Interior Alaska

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Low-lying forested areas underlain by ice-rich permafrost may develop into thermokarst wetlands when permafrost thaws and no longer supports the ground above the water table. Inundation of the subsided land leads to tree death and the emergence of aquatic vegetation. The objective of our study is to determine whether soil respiration rates differ between forested areas having permafrost and adjacent thermokarst wetlands. We measured soil respiration rates weekly to biweekly during the 2003 growing season at a black spruce forest near Fairbanks, Alaska that contains thermokarst wetlands. The forest is underlain by permafrost at depths ranging from 40 to 50 cm, but in several areas thermokarst wetlands have formed due to the melting of permafrost to below 2 m depth. Soil respiration was measured at five locations in thermokarst wetland areas and at five adjacent forested areas having permafrost. Soil temperature and depth to ice was also measured at each location. Soil respiration rates at both the thermokarst and permafrost areas were similar in May, averaging 0.42 and 0.38 mmol CO_2 m^{-2} hr^{-1} respectively. Respiration increased in June to maximum measured rates of 1.55 mmol CO_2 m^{-2} hr^{-1} at the thermokarst sites, and 0.98 mmol CO_2 m^{-2} hr^{-1} at the permafrost sites. There was more variation in respiration rates among the thermokarst wetland sites than among the permafrost sites.

B31C-0307 0830h POSTER

Methane and Carbon Dioxide Production and Methane Oxidation Potential From a Melt Feature in the Discontinuous Permafrost Zone of Northern Alberta, Canada

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With warming in northern latitudes, collapse scars have developed in permafrost regions resulting in wet bogs dominated by *Sphagnum* species with some vascular plants. The amount of methane and carbon dioxide produced and emitted can have an important impact on global atmospheric budgets. From a collapse scar in the discontinuous permafrost zone of northern Alberta, Canada, peat cores were taken in order to estimate the potential CH_4 production (PMP), potential anaerobic and aerobic CO_2 production (PCP), and potential CH_4 oxidation (PMO), as well as the effect of temperature on all three processes. A depth profile of PMP and anaerobic PCP and their response to temperature was determined on 3 cores from the central portion of the collapse scar in August 2003. The cores were field extruded and representative slices from 0 to 100 cm were made anaerobic and incubated at 2C, 12C and 22C. Additionally, the same temperature regime was used to examine the effect of temperature on PMO, and aerobic PCP from 3 cores collected during the same month. PMP peaked between 10 to 15 cm below the water table with an average production of 0.08 μg CH_4 g^{-1} d^{-1}. Anaerobic PCP was greatest between 0 to 5 cm below the peat surface in all cores with an average production of 0.65 μg CO_2 g^{-1} d^{-1}. Anaerobic PCP at peak PMP depth was 0.19 μg CO_2 g^{-1} d^{-1}. The average anaerobic PCP to PMP ratio for core depths with significant PMP was 1.4 (mole/mole). At peak PMP depth the average Q_{10} response was 8.6 for 2 to 22C and for anaerobic PCP the average Q_{10} response at the depth of maximum production was 1.7 for 2 to 22C. Incubation temperature had a greater effect on PMP and anaerobic PCP between 2 and 12C then it did between 12 and 22C. On average, PMO was greatest 12 cm below the water table with a peak oxidation of 1.2 μg CH_4 g^{-1} d^{-1} at a depth of 25 to 30 cm. The area of maximum PMO and PMP occurred at the same depth interval, 10 to 15 cm below the water table. Aerobic PCP was greatest at a depth of 0 to 5 cm with an average production of 2.2 μg CO_2 g^{-1} d^{-1}. The average aerobic PCP to anaerobic PCP ratio for depths 0 to 80 cm was 3.2.

B31C-0308 0830h POSTER

Effect of *Eriophrum* spp. on Methane Emission and Methane Production Potential in a Melt Feature Within the Discontinuous Permafrost Region of Northern Alberta, Canada

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Increasing temperatures in northern latitudes have led to the development of collapse scars which are formed as the ice below the permafrost melts allowing the surface peat to sink, creating a wet depression. Collapse scars are *Sphagnum* dominated bogs, which may contain vascular wetland plant species. Some vascular plant species are associated with increased CH_4 fluxes from wetlands. This experiment was designed to determine the effect of *Eriophrum* spp. (cotton grass) on methane (CH_4) emission from these collapse scars. Surface CH_4 emission and CH_4 production potentials from core incubations were determined at the peak of methane flux for the growing season, August 2003. Surface fluxes were determined by using a static chamber technique, while CH_4 production potential was determined by taking 60cm cores and incubating representative slices at 10cm intervals in sealed anaerobic flasks. Headspace samples were taken every 12hr for 48 hours to determine rate of CH_4 production. Emission measurements of eight surface plots, four containing moss-only and four with moss and *Eriophrum*, indicated significantly higher CH_4 emitted from the *Eriophrum* plots (4.61 mg CH_4 $m^{-2}h^{-1}$ ($\pm$2.41 S.D.)) than from moss-only plots (1.16 mg CH_4 $m^{-2}h^{-1}$ ($\pm$0.85 S.D.)) (ANOVA, α= 0.05). For production potential, twelve cores were taken; six in the middle of *Eriophrum* tussocks, and six in areas with only moss on the surface. We hypothesized that *Eriophrum* peat would have increased CH_4 production over the moss-only peat. Core collection and incubation showed very little difference in CH_4 production potential between the two areas. Mean CH_4 production potential was slightly greater in the top 30cm of the *Eriophrum* peat as compared to the moss-only sites. Below this depth, moss-only peat produced slightly more CH_4 than peat from *Eriophrum* sites. It is possible that *Eriophrum* root exudates at the 10 to 30cm depth (region of peak production) along with the ability of their vascular tissues to provide a conduit for CH_4 may contribute to the increased CH_4 production and emission observed in these melt features.

B31C-0309 0830h POSTER

Enhanced N Deposition and Peatland Carbon Stocks in Boreal Alberta

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Increased deposition of reactive nitrogen due to anthropogenic activities may stimulate plant growth and soil C turnover in N-limited ecosystems. Many peatland ecosystems are particularly sensitive to nitrogen deposition due their ombrotrophic nature. Here, we capitalize on a regional gradient of N deposition associated with several decades of oil sands mining. At six peatlands varying in atmospheric N loading (modeled from 1.45-3.26 kg N ha^{-1} yr^{-1}), we measured *Sphagnum fuscum* net primary productivity (NPP). NPP rates were higher at Steepbank Bog (mean of 600 g m^{-2} yr^{-1}) than at the five sites with lower N deposition (pooled mean of 182 g m^{-2} yr^{-1}). At the site with the highest (Steepbank Bog) and lowest (Bleak Lake Bog) N loading, we quantified rates of C storage by ^{210}Pb dating. Over the past 30 years of mining activity, rates of vertical peat accumulation were higher at Steepbank Bog (19.4 $\pm$0.4 cm) than at Bleak Lake Bog (13.9 $\pm$2.0 cm). However, there were no differences between sites in cumulative C storage over this 30-yr period (Steepbank: 5.0 $\pm$0.2 kg C m^{-2}, Bleak Lake: 5.0 $\pm$0.4 kg C m^{-2}). Together, these data suggest that increased N availability stimulates plant growth rates, leading to greater vertical accumulation of peat. However, enhanced N deposition does not appear to influence C storage in these sites, possibly due to lower peat bulk density and/or greater microbial activity.

B31C-0310 0830h POSTER

Potential enhancement of CH_4 emission in North Slope Wetlands of Alaska by Caribou

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Methane (CH_4) emissions were measured just after two caribous traversed wetland sites of the North Slope of Alaska using a static chamber technique during the summer. The maximum value (308 mgCH_4-C/m^2/day) in wetlands was found as a result from the stimulated ebullition by caribou passage during seasonal post-calving migration. The estimated CH_4 emission by caribou disturbance ranged 8.0 to 15 x 10^9 gCH_4-C/season, which was almost comparable to the background CH4 emission range of 3.6 to 7.0 x 10^9 gCH_4-C/season. This finding suggests that enhancement of CH_4 emission due to disturbance of wetlands should not be overlooked for the better understanding of global CH_4 cycle.

B31C-0311 0830h POSTER

Variation in frost-boil morphology and associated vegetation characteristics along a climatic gradient

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A team of researchers from the US and Canada has been conducting a series of investigations of the interactions of climate, vegetation, and permafrost in the study Biocomplexity of Arctic Frost-Boil Ecosystems. Frost-boils are small-scale patterned ground features formed by the seasonal expansion of ice lenses and the upward movement of soil during annual freeze thaw cycles in permafrost landscapes. The displacement of soils disrupts the vegetation layer, creating a mosaic of barren circular patches and vegetated interboil areas. The morphology of these features and the extent to which vegetation patterns are affected by the displacement varies with climate. We have been working at a network of 11 study sites along a transect from Happy Valley, Alaska to Ellef Ringnes Island, Canada. The project has five major components: Climate and Permafrost, Soils and Biogeochemical Cycling, Vegetation, Ecosystem Modeling, and Education. As part of the education component, students in the class Arctic Field Ecology have been addressing the question of how biodiversity patterns vary between boil and interboil areas within a given site and along the climatic gradient. In order to develop an understanding of variation in frost-boil morphology we analyzed boil and interboil differences in thaw depth, frost-boil width, micro relief, and vegetation cover from a series of 42 transects at six of the Biocomplexity study sites in Alaska and Canada. We present this variation in series of diagrams representing morphology typical of frost-boil patterning along a gradient from low to high arctic and of patterns in vegetation associated with frost boil morphology.

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B31C-0312 0830h POSTER

Structure and Functioning of Phytoplankton Community of a Humic Lake Littoral Under Atmospheric Carbon Dioxide Enrichment

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The flux of energy and carbon across the ecosystem can give an integrated measure of the whole-ecosystem response to environmental perturbation such as climate change. CLIMFRESH was an international, cooperative research project that focused on the response of lake ecosystems to increased atmospheric CO_2 concentration. The experimental set up where temperature was constantly kept 3°C above the ambient was built in an experimental greenhouse (area ca. 550 m^2, volume ca. 1800 m^3) at Lammi Biological Station, southern Finland. The set up consisted of 4 experimental large-scale flow-through systems, which were each 7 m wide and 13 long with a water volume of ca. 65-70 m^3 and a retention time of 5-7 days. Each system had a very shallow littoral zone for emergent macrophytes and beyond that a zone for submerged plants with a maximum depth of ca. 1.5 m. The experiment was duplicated and two of the ponds were in the compartment with higher atmospheric CO_2 and two in the ambient CO_2 thus serving as controls. The target concentration of increased atmospheric CO_2 was 700 micromol mol^{-1}. Samples of water chemistry and on biological stock and process parameters were taken once a month throughout the three-year study period over the open-water period. Special interest was paid on studies on phytoplankton community and productivity. The results revealed that the exposure of the whole ecosystem to higher atmospheric CO_2 changed the phytoplankton community structure so that e.g. chrysophytes and cryptophytes were more abundant under higher CO_2 concentration. No clear changes in contribution of cyanobacteria were detected. There were time-dependent differences in N:P ratios of particulate matter so that in early summer the ratios were higher under exposure to extra CO_2. The same was true for N:P of inorganic nutrients as well as C:P ratios. These results indicate that climate change via increased atmospheric CO_2 concentrations can change the communities of planktonic primary producers in a way which can be reflected higher up in the food web.

B31C-0313 0830h POSTER

CO_2 Fluxes From a Boreal Lake in Relation to Biological Activities

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Eddy covariance instrumentation with ultrasonic anemometer (USA-1, Metek, Germany) and closed-path infrared gas analyser (LI-7000, Li-Cor Inc., Lincoln, Nebraska, USA) was set up for continuous CO_2 flux measurements on a small humic lake in the boreal zone in southern Finland. The measurements were started at the beginning of June 2002 and continued until the lake froze over. The lake was sampled weekly for chemical data and biological stock parameters. Epilimnetic primary production and community respiration was also measured once a week to relate the CO_2 fluxes to the functioning of the lake ecosystem. Results showed diurnal as well as seasonal differences in CO_2 fluxes. In summer average hourly fluxes were always slightly negative around noon and early afternoon but in the morning and evening efflux was clear. Largest effluxes coincided with the highest epilimnetic water temperatures. In autumn diurnal variation in CO_2 flux was smaller and CO_2 was emitted from the lake throughout the day. However, the flux values at the time of fall turnover were always fairly small. Also primary productivity and community respiration showed seasonal changes which could be related to the CO_2 fluxes. Relatively high community respiration confirmed the general role of the lake as a source of CO_2.

B31C-0314 0830h POSTER

Inter-Lake Variations in the Isotopic Signatures of Dissolved Inorganic Carbon in Lakes: Within-Lake Processing Versus Watershed Loading

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We compared δ^{13}C-DIC in 72 lakes from diverse regions using literature data, as well as new data for 32 lakes in the Northern Highland Lake District of northern WI and the Upper Peninsula of Michigan. We found that geochemical variables (pH, [DIC] and alkalinity) account for a large portion of the inter-lake variation in statistical models. However a process-based model including atmospheric gas exchange, inorganic carbon speciation, and ecosystem metabolism was evaluated for the Northern Highland Lakes. The model provides a reasonable fit to the data compared with the simplest of the statistical models for lakes in which respiration exceeded gross primary production (heterotrophic lakes; 75% of lakes sampled). Lakes for which gross primary production exceeded respiration (autotrophic) were not fit well by the model. The model demonstrates that external inputs of DIC (e.g. groundwater) have relatively little influence on d13C-DIC and therefore, results from the comparisons and models suggest that internal lake processes are important for determining δ^{13}C-DIC in lakes.

B31C-0315 0830h POSTER

Formation of Colloidal and Particulate Organic Carbon in Boreal Streams and Lakes

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The boreal lakes of Ontario store large amounts of carbon in their sediments, second only to peatlands in magnitude. This carbon is exported to these oligotrophic lakes primarily as dissolved organic carbon (DOC) from adjacent peatlands by streams, however, the mechanisms by which the sediments accumulate this carbon as particulate organic carbon (POC) are not understood. It is important that we comprehend these processes in order to understand how disturbance could affect this storage. Floc formation has been observed in irradiated boreal stream and lake waters. Samples irradiated under low UV intensities produced more floccular material compared to samples irradiated under high UV intensities, while little material was observed in dark controls. TEM work has indicated that microbial extracellular reactions may initiate this floc formation, hence, both bacteria and UV radiation may play a role in POC formation. Data from fractionated chemical analyses and TEM imaging will be presented.

B31C-0316 0830h POSTER

Landscape controls on streamwater carbon export during spring flood in northern Sweden

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Fifteen boreal catchments in northern Sweden were monitored during the spring flood season of 2003 to examine spatial and temporal variations in streamwater acidity, inorganic carbon (DIC) and dissolved organic carbon (DOC), and their relationship with catchment characteristics. The sites were sampled in a nested design resulting in catchments varying in size from 0.1 to 67 km^2, and varying widely in relative areal coverage of forest, mire and lake, three major features of the Swedish boreal landscape. Although wetland-dominated catchments had higher overall mean DOC concentration than did forested catchments, the spring flood had a moderating impact on this difference: DOC concentrations increased by two to four-fold in forested catchments, while decreasing by nearly 50% in the wetland-dominated catchments. Catchment characteristics, in particular catchment size and the areal extent of wetlands and humic lakes, appear to play a large role in regulating streamwater acidity and DOC concentrations during spring flood. Patterns in pH largely follow patterns in DOC concentration for these streams, which contain high levels of humic acids. During spring snowmelt, pH remained at a consistently low level in headwater mire sites, but dropped substantially in all other catchments. The pH decline was less pronounced in the larger, more well-buffered streams. DIC export was small relative to DOC, but DIC concentrations were substantial in headwater streams prior to the spring snowmelt, when many of the streams were oversaturated with respect to CO_2.

B31C-0317 0830h POSTER

Organic Carbon Sources in Coastal Southeast Alaskan Streams

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Dissolved organic matter (DOM) is abundant in southeast Alaskan watersheds and plays an important role in the biological and physical processes in these aquatic systems. Nearly 30% of the land area in southeast Alaska is classified as wetlands, a large proportion of which are peatlands. Peatlands are thought to provide substantial DOM to surface waters. Another important source of carbon to streams is spawning anadromous salmon. This study examines how streamwater concentrations of DOC are influenced by 1) catchments soils and vegetation, particularly wetland extent and 2) the presence or absence of anadromous fish. Our goal is to characterize the quantity and quality of different DOM sources and to develop an understanding of how these sources influence seasonal trends in streamwater DOM in coastal freshwater systems in southeast Alaska. Surface water and well samples were collected on two contrasting streams near Juneau, Alaska: Peterson Creek, a brownwater, high-carbon stream in a wetland-dominated catchment and McGinnis Creek, a clearwater stream draining upland spruce forest and alpine tundra. Both streams have runs of pink, coho, and chum salmon from July-September. Streamwater DOC concentrations on Peterson Creek averaged 5-6 mg C L^{-1} during the early summer and increased to 8-12 mg C L^{-1} during late July and August. Streamwater DOC concentrations on McGinnis Creek were typically less than 1 mg C L^{-1} during the early summer but increased dramatically to 4-9 mg C L^{-1} during spates in August. Well samples collected upslope from the streamwater sampling sites on Peterson and McGinnis Creeks had a similar range in DOC concentrations (10-40 mg C L^{-1}), however the wells on McGinnis Creek showed much higher seasonal variability. Our initial results suggest that the seasonal increase in DOC in both streams is primarily associated with the flushing of soluble organic carbon from catchment soils by late summer rains. However, leaching of DOC from salmon carcasses may also be significant in July-September. We are currently using chemical fractionation and UV spectroscopy to determine how the character and reactivity of DOC in Peterson and McGinnis Creeks changes on a seasonal basis. In addition, fluorescence spectroscopy is being used to assess seasonal changes in the precursor material for streamwater DOC in both study catchments.

B31C-0318 0830h POSTER

Biogeochemical Tracers in Arctic Rivers: Linking the Pan-Arctic Watershed to the Arctic Ocean (the PARTNERS project)

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The Arctic is undergoing unusual and apparently progressive changes in the land, ocean, and atmospheric components of the hydrologic cycle that could have long-term consequences for both local and global climate. Understanding sources and fates of river discharge is important because rivers make an enormous contribution to the freshwater budget of the Arctic Ocean. The overall objective of the PARTNERS project is to use river water chemistry as a means to study the origins and fates of continental runoff. Through a collaboration among scientists in Russia, Canada, and the United States, sampling was initiated during summer 2003 on the downstream reaches of the six largest arctic rivers (Yenisey, Lena, Ob', Mackenzie, Yukon, Kolyma). Samples are being analyzed for a wide range of constituents, focusing on compounds that can be used as tracers of river water in the Arctic Ocean or that give clues about watershed sources or processes. Sampling will occur for four years (2003-2007), with

sampling frequency peaking at 7X per year during 2004 and 2005. To insure that the riverine endmember data being collected by the PARTNERS project is most relevant, we are actively coordinating with oceanographic research efforts. This multinational, multidisciplinary project is greatly improving our understanding of land-ocean linkage in the pan-Arctic watershed.

B31C-0319 0830h POSTER

Detecting and Analyzing Trends in Freeze Thaw Cycles of High Northern Latitude Soils Using Passive Microwave Satellites Since 1988

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In the far north, soil respiration rates are controlled by a complex interaction of soil freeze state, active layer depth, soil moisture and substrate form and availability. The freeze thaw boundary represents a significant first order constraint on soil respiration and is detectable using satellite imagery. Using satellite data from the Special Sensor Microwave/Imager (SSM/I) spanning the period 1988-2002, we developed a technique to detect the timing of freeze and thaw of soils north of 45 degrees N. We analyzed both biome and site level trends in the onset of freeze and thaw since 1988. Our results indicate that the spring thaw advanced in both tundra and boreal forests of North America, and in tundra and larch forests in Eurasia. Fall freeze was delayed in both boreal and tundra North America, but advanced in both tundra and larch forests in Eurasia. Boreal Eurasia maintained nearly constant freeze and thaw timing since 1988. The growing season length increased in North America, but remained nearly constant in Eurasia due to both an earlier thaw and freeze in tundra and larch ecosystems.

B31C-0320 0830h POSTER

Mapping Wetlands of the North American Boreal Zone from Satellite Radar Imagery

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The accurate assessment of spatial and temporal distributions of wetlands can have a large impact in improving the estimates of the global net carbon exchange. Synthetic aperture radar (SAR) sensors are well suited to monitoring wetlands because of their ability to detect various combinations of standing water and vegetation conditions. They also penetrate cloud cover and do not require solar illumination, allowing the collection of frequent seasonal data. The recent availability of large-scale satellite SAR mosaics is making it possible to generate baseline wetlands map of the north American boreal zone, where it is hypothesized to exist a substantial carbon sink, and 15-20 percent of the land surface is comprised of wetlands. The present work utilizes the summer and winter JERS-1 mosaics of the region as well as several large-scale coverages of ERS-2 for mapping the north America boreal wetlands. As an intermediate product, an open water map of the area is also being generated, derived from 100-meter resolution JERS-1 SAR mosaic products. We present a large-scale wetlands map covering large parts of Alaska and Canada, generated using a classification algorithm applied to coregistered JERS-1 (L-band HH polarizations) and ERS-2 (C-band VV polarization) SAR mosaics. The former exists for almost the entire area of Alaska and Canada, whereas currently we have access to the latter only for Alaska and Western Canada. The classification method is based on a rule-based decision-tree algorithm, and divides the landscape into the following classes: open water (possibly with sparse emergent vegetation), flooded woody vegetation (e.g., forests), flooded herbaceous vegetation, nonflooded woody vegetation, nonflooded herbaceous vegetation, and nonflooded-nonvegetated. The five standard Canadian wetlands classes of fens, bogs, swamps, marshes, and open water can be mapped into one or more of our vegetation-based wetlands classes. Several local-scale products have been validated using specific study sites. More extensive validations are in-progress or planned in cooperation with various wetlands research groups. This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, and at The University of Michigan under a contract with the National Aeronautics and Space Administration.

B31C-0321 0830h POSTER

Satellite Remote Sensing of Landscape Freeze/Thaw State Dynamics for Complex Topography and Fire Disturbance Areas Using Multi-Sensor Radar and SRTM Digital Elevation Models

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The annual freeze/thaw cycle drives the length of the growing season in the boreal forest, and is a major factor determining annual productivity and associated exchange of CO_2 with the atmosphere. Variations in freeze/thaw processes are spatially and temporally complex in boreal environments, particularly in areas of complex topography and in fire disturbance regimes. We investigate the spatial and temporal characteristics of seasonal freeze/thaw dynamics in complex boreal landscapes, as derived from radar backscatter measured with ERS (C-band, VV polarization, 200m resolution) and JERS-1 (L-band, HH polarization, 100m resolution) Synthetic Aperture Radars (SARs), and with the SeaWinds scatterometer (Ku-band, 25km resolution). C- and L-band backscatter are applied to characterize freeze/thaw transitions for a chronosequence of recovering burn sites near Delta Junction, Alaska, and for a region of complex topography on the Kenai Peninsula, Alaska. We characterize differences in radar-derived freeze/thaw state, examining transitions over complex terrain and landscape disturbance regimes. In areas of complex terrain, we explore freeze/thaw dynamics related to elevation, slope aspect and varying landcover. In the burned regions, we explore the timing of seasonal freeze/thaw transition as related to the recovering landscape, relative to that of a nearby control site. We apply in situ biophysical measurements, including flux tower measurements to validate and interpret the remotely sensed parameters. A multi-scale analysis is performed relating high-resolution SAR backscatter and moderate resolution scatterometer measurements to assess trade-offs in spatial and temporal resolution in the remotely sensed fields. A temporal change discriminator is applied to classify time series radar imagery to classify the landscape freeze-thaw state. We apply a 30m-resolution digital elevation model (DEM) derived from Shuttle Radar Topography Mission (SRTM) data to orthorectify the time series SAR imagery over the complex terrain site. This DEM was integrated with the SAR imagery to examine elevation and slope aspect effects on freeze/thaw transitions. Scaling assessments of the relationship between SAR and SeaWinds backscatter provide a means for determining sub-grid spatial variability in land cover, terrain and freeze/thaw processes, based on semi-variogram analyses. Results show that the high-resolution SARs may be applied to map freeze/thaw transitions in complex landscapes. In regions of complex terrain, dynamics related to elevation and slope aspect are delineated. Fusion with accurate DEM information as provided by SRTM facilitates orthorectification and analysis of terrain effects. The SARs also observe distinguishable differences in backscatter amplitude response and in the timing of freeze/thaw transitions associated with varying disturbance regimes driven by forest fire. These findings demonstrate the importance of considering landscape heterogeneity for development of remote sensing techniques for monitoring phenological processes across complex, heterogeneous landscapes in boreal ecosystems. This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, and the University of Montana under contract with the National Aeronautics and Space Administration.

B31C-0322 0830h POSTER

Satellite Observations of Spatial Patterns and Interannual Variability in Spring Thaw and Terrestrial Net Primary Production for the Pan-Arctic

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Spatial and temporal variability in the timing of spring thaw is a major driver of regional vegetation activity and net carbon exchange with the atmosphere at high northern latitudes. We conducted a temporal classification of the primary spring thaw event from 1988 to 2001 across the pan-arctic basin and Alaska using passive and active microwave remote sensing measurements from the Special Sensor Microwave Imager (SSM/I) and SeaWinds scatterometer. Spatial patterns and interannual variability in the timing of spring thaw are examined in relation to regional biospheric activity indicated by atmospheric CO_2 measurements and terrestrial annual net primary production (NPP) derived from AVHRR Pathfinder and MODIS satellite data. The timing of the primary terrestrial seasonal thaw event in spring spans a 1.8 month period across the region with interannual variability on the order of 1 week (+/-46%), while spatial and interannual variability in NPP is found to be on the order of 3 Mg C ha^{-1} yr^{-1} (+/-79-94%). Satellite observations of the timing of spring thaw correspond significantly to seasonal patterns and interannual variability in the timing of carbon uptake and associated vegetation activity as indicated by atmospheric CO_2 measurements and spatial patterns of annual NPP derived from global satellite observations. The timing of satellite based spring thaw measurements corresponds directly to the timing of regional net carbon uptake in spring as indicated by atmospheric CO_2 measurements, though interannual variability in spring thaw does not necessarily correspond to similar changes in NPP. These differences are attributed to the coarse spatial scale of GCM meteorological inputs used to derive satellite based NPP results and the influence of seasonal temperature, radiation and precipitation patterns on NPP. Satellite observations of seasonal thaw appear to provide a consistent, indirect measure of regional biospheric activity at high northern latitudes. This work was performed at the University of Montana, and at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

B31C-0323 0830h POSTER

Trends in Pan-Arctic Springtime Thaw Monitored With Spaceborne Microwave Radiometry

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Land surface seasonal transitions between predominantly frozen and thawed conditions occur each year over roughly 50 million square kilometers of Earth's Northern Hemisphere, profoundly affecting surface meteorological conditions, ecological trace gas dynamics, and hydrologic activity. The size and remoteness of arctic and boreal ecosystems, however, pose a challenge to quantification of both terrestrial ecosystem processes

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and their feedbacks to regional and global climate conditions. Boreal and arctic regions form a complex land cover mosaic where vegetation structure, condition and distribution are strongly regulated by environmental factors such as moisture availability, permafrost, growing season length, disturbance and soil nutrients. The timing of spring thaw in particular, can influence boreal carbon uptake dramatically. With boreal forests accumulating 1% of their annual total accumulated carbon each day of the growing season, variability in timing of spring thaw can trigger total interannual variability in carbon uptake on the order of 30%. The ability to quantifiably apply multi-year observations of landscape freeze-thaw status of 1- to 2-day temporal fidelity to ecosystem process studies in high-latitude regions will allow improved assessment of modeled processes for long-term monitoring. We utilize brightness temperature measurements from the Special Sensor Microwave Imager (SSM/I) and the Scanning Multichannel Microwave Radiometer (SMMR) to examine trends in the timing of springtime thaw across the pan-boreal high latitudes since 1979. We apply a temporal discrimination technique to these data sets to determine the timing of the primary springtime thaw events across the pan-boreal high latitudes. We apply data from biophysical monitoring stations to quantify the sensitivity to surface freeze-thaw state transitions and associated vegetation biophysical processes under a variety of terrain and landcover conditions. We develop a time series of landscape freeze-thaw products at regional and pan-boreal scales across multiple years. These time series products demonstrate the highly complex spatial and temporal nature associated with these critical processes. Results show a trend toward an advance in panboreal springtime thaw over the past years, corroborating similar findings relating to advance in vegetation green-up. The continued capability for monitoring seasonal freeze-thaw cycles across the pan-boreal region provides a means for assessing interannual variability and, eventually, longer-term trends in ecosystem function. This work was performed at the Jet Propulsion Laboratory, California Institute of Technology, and the University of Montana under contract with the National Aeronautics and Space Administration.

B31D MCC: Level 1 Wednesday 0830h

Ecosystems in Flux: Isotopes as Indicators of Ecosystem Change I Posters *(joint with A, H, OS)*

Presiding: **H Jahren,** Johns Hopkins University**; T W Boutton,** Texas A&M University

B31D-0324 0830h POSTER

Examination of an Oligocene Lacustrine Ecosystem Using C and N Stable Isotopes

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Stable isotopes of C and N are used to reconstruct the fossil Oligocene (25.8Ma) ecosystem at Lake Enspel, Westerwald, Germany. Enspel was a steep-sided, deep maar lake with anoxic bottom waters. Upon dying, terrestrial and aquatic organisms sank into the sediment where they were colonized by bacteria. These bacteria quickly became fossilized, preserving morphological detail and large amounts of organic matter from the original macroorganism. Carbon and nitrogen are sufficiently preserved in these fossils to permit stable isotope analysis. Stable isotopic signatures identify several trophic levels, including primary producers (terrigenous and aquatic plants, diatoms), primary consumers (tadpoles, some insects), and secondary consumers (carnivores such as fish). Primary producers are associated with depleted d13C and d15N values, primary consumers such as flies are one trophic shift higher, and fish are another shift higher. Signatures for the fish species show heavy-isotope enrichment correlated with increasing length, indicating an increasingly carnivorous diet. This study marks the first attempt to reconstruct a complete fossil ecosystem using stable isotope analysis, and confirms that techniques used to study modern food webs can be applied to extinct webs as well.

B31D-0325 0830h POSTER

Distribution and Sources of Lignin Monomers in Late Quaternary Sediments From Southwestern Coastal Plain of Taiwan

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In an effort to understand paleoenvironmental changes of the southwestern coastal plain of Taiwan over the past 50K years, we employed molecular and stable isotope techniques to sediment cores to study shifts in organic carbon input and plant communities. Preliminary results show that, during the Holocene (the last 10K yrs), large shifts in bulk stable carbon isotope values are observed suggesting either shifts C3/C4 communities or changes in algal productivity. Moreover, lithologic variations in lignin monomer proxies indicate wide a variation in the degree of microbial oxidation based on elevated vanillyl Acid/Aldehyde ratios. The carbon-normalized yield of 8 vanillyl, syringyl, and cinnamyl phenols shows wide variation during periods in the late Pleistocene and Holocene. The Holocene-Pleistocene boundary exhibits a sharp change of TOC, vanillyl Acid/Aldehyde ratio, and lignin yield. However, variations still exist between cores due to different regional sedimentary environments. Studies are ongoing to relate nitrogen and sulfur cycling to organic carbon input.

B31D-0326 0830h POSTER

Soil gas 13C Values and CO2 Concentrations on the Southeast Slope of Mauna Kea: Implications for Palaeoclimate and Hydrogeology

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As part of the Hawai'i Scientific Drilling Project (HSDP), an elevational transect on the southeast slope of Mauna Kea Volcano, Hawai'i, was sampled for soil gas CO2 13C over a one-year study interval. Our objective is to determine the principle influences on the 13C values of dissolved inorganic carbon (DIC) that is contributed to groundwater recharged in the area. Groundwater DIC from the HSDP drill hole, dated to 2200 B.P., had a carbon isotopic value of -12$^{o}/_{oo}$. The D/H and 18O values of the water indicate that the average elevation of recharge is at 2000 m on Mauna Kea. It was postulated that this 13C was controlled mainly by the photosynthetic pathway of the predominant vegetation at this elevation at the time of recharge. If this is true, the current 13C values should have changed as a result of the conversion of the formerly forested Mauna Kea slopes to grassland in the past 2200 years. Preliminary results support this hypothesis. Present day 13C values range from -12$^{o}/_{oo}$ in grasslands at 2000 m ASL to -24$^{o}/_{oo}$ in the lower elevation forested areas. With the soil gas values of -12$^{o}/_{oo}$ in the grasslands, fractionation between soil gas and bicarbonate in groundwater would cause the DIC in groundwater to have values of -4$^{o}/_{oo}$ today. The conversion of this area to grassland approximately 200 years ago and the introduction of exotic C4 grasses are assumed to be the causes of the difference, as C3 trees have lighter values than C4 grasses. Other areas of the transect follow predicted patterns for vegetation type. Analysis of the data is continuing in order to elucidate diurnal and annual trends in the soil gas ä13C values and CO2 concentrations.

B31D-0327 0830h POSTER

Drought Cycles in Northern New Mexico, Isotopic Evidence of Forest Stress

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Severe droughts in the southwestern United States are shown to occur about every 50 years. Accompanying these droughts, disturbance varieties such as fire or insect infestation produce ecosystem shifts in forest species composition. Specifically, in the Jemez Mountains of northern New Mexico Mountains shifts from Ponderosa pine (*Pinus ponderosa*) to pinon (*Pinus edulis*)/juniper (*Juniperus monosperma*) to juniper forests have occurred in the last 100 years. Stable carbon isotope ratios of needle tissues and cellulose from tree rings were measured to determine the periodicity and the severity of regional drought in the Jemez Mountains. Pinon and Ponderosa pines were investigated over an elevation gradient to determine the temperature and precipitation thresholds necessary to cause significant changes in water use efficiency, in isotope ratios, and in large-scale species die-off. Samples of organic δ^{13}C in whole leaf tissue were collected from pinon species from attached cohorts where a total of 7 years could be measured. The δ^{13}C of cellulose from tree ring samples were collected from both pinon and Ponderosa species where select years over the past 100 years were analyzed. During periods of intense drought, greater than 4 successive years, steady enrichments in ^{13}C were observed with highest levels of stress occurring at the lowest elevation sites. These results suggest that δ^{13}C can be used as a marker for drought in both needle and wood tissues, that the threshold for stress and large scale forest die-off occur at low elevation, and that there is about a 50 year periodicity in severe drought observed in the northern New Mexico region.

B31D-0328 0830h POSTER

Tree-ring Indices and Isotope Signatures of Pinus ponderosa Related to Historic Ozone Changes Outside Los Angeles

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Ozone concentrations in the Los Angeles (LA) basin were at historic highs in the late 1970s. Since that time Clean Air regulations have helped lower ozone, but little is known of the long-term vegetation responses. Extensive research has used tree-ring indices together with the physiological and environmental information stored in the δ^{18}C and δ^{18}O signatures of tree-ring cellulose to understand past climates. Here, we used the forty-year ozone record from Camp Paivika, CA, the site in the San Bernardino mountains of the LA basin with both the longest record and the highest values, to determine climate versus ozone impacts on basal area increment and δ^{13}C and δ^{18}O signatures for Ponderosa Pine. Annual growth increment was significantly related to ozone and temperature but not precipitation. δ^{13}C showed the typical climatic pattern of becoming more enriched in warm dry years, but was more strongly related to ozone independent of climate effects. δ^{18}O was also enriched in warm, dry years, but was most strongly related to annual growth increment and showed no relationship with ozone. The relationship between δ^{18}O and growth is likely due to alterations in evaporative enrichment within the foliar tissues. Our results will be discussed in light of physiological processes and environmental variation responsible for alterations in δ^{13}C and δ^{18}O signatures.