The decline in sea ice extent in the Arctic Ocean and its marginal seas since the 1950s has led to some documentation of, and even more speculation about, impacts on the arctic ecosystem. We used the stable carbon isotope signatures of primary producers, phytoplankton and sea ice algae, from the Beaufort Sea to examine relative shifts in the proportion of source carbon in biota and relate changes to sea ice conditions. Schell (2000), using del13C along baleen plates of bowhead whales as a time series proxy, proposed that the carrying capacity of the Western Arctic has declined by 30 to 40% over the past five decades. While this contention is not without challenge, it remains as the accepted paradigm to account for major ecological changes. However, McRoy et al. (2001), using seasonal nutrient depletions on the Bering Sea shelf for the past 20 years, found no decline in primary productivity. Using a simple mixing model of the two primary sources of carbon to whale diets we estimated the proportion of ice algae and phytoplankton in the food web. The data implicate a decline in the amount of ice algal carbon, rather than a decrease in ecosystem productivity, in the bowhead whale diet as an explanation for the trend in isotope values in baleen. The result correlates well with arctic sea ice extent over the period. Independent data from a productivity budget of the Bering Sea indicate that the heavy carbon signal from ice algae could increase the overall POM del13C by up to $2.5^{o}/_{oo}$, supporting the idea. Also, a 100-year time series of carbon isotopes in POM from a core in an anoxic bay in the Aleutian Islands correlates with sea ice extent, further supporting the view that proportions of source carbon in the ecosystem have changed.

B41A CC: 220 C-E Thursday 0830h

General Biogeochemistry Posters

Presiding: **N T Roulet,** McGill University**; T Moore,** McGill University

B41A-01 0830h POSTER

Sea Ice Biology in Polar Regions: State of the Art and Perspectives in the IPY

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Recent global warming in the Arctic Ocean predicts shifting of ice-edge to the north, decreasing of sea-ice thickness and surface, and increasing of ice-open areas. This scenario suggests increasing of biological productivity and duration of vegetation period, and intensification of regeneration processes in the sea ice-upper ocean system. However, at present the evidence of impacts of global change on the sea ice ecosystem is sparse or uncertain, though there are fragmentary indications of recent changes. As established now, the biological community response to global change is most likely in the regions, where the sea ice retreat is rather remarkable, e.g., in the region of Beaufort Gyre (Melnikov et al., 1998; Melnikov, 2000; Melnikov and Kolosova, 2001; Melnikov et al., 2001, 2002). Assessment of the recent sea-ice ecosystem dynamic and modeling its potential changes will allow us to estimate and forecast potential changes within the sea ice-upper water system and consequent ecological effects on higher trophic levels including birds, marine mammals and benthic organisms. Recently, one of the major ecological issues in polar regions is to figure out natural variations in the composition, structure and function of the marine ecosystems and variations due to anthropogenic factors. For example, overfishering of krill around Antarctic Peninsula in 70th was a reason in reconstruction of natural population structure in this region. In order to understand and distinguish both variations it is necessary to conduct a long-term ecological monitoring in the Southern Ocean (SO). This research will be the base of a predictive understanding of the Antarctic marine system, including its multiple modes of variability across timescales, its interaction with coastal systems, and its relationship with the global climate system. References 1. Melnikov I.A., Sheer B., Wheeler P., Welch B., 1998. Preliminary Biological and Chemical Oceanographic Evidence for the Long-Term Warming Trend in the Arctic Ocean (current materials of the SHEBA Ice Camp, Beaufort Sea). SEARCH Workshop, August, 1998. 2. Melnikov, I.A. 2000. The Arctic sea ice ecosystem and global warming. In: Huntington, H.P., (ed.). Impacts of changes in sea ice and other environmental parameters in the Arctic: final report of the Marine Mammal Commission Workshop, Girdwood, Alaska, 15-17 February 2000. Bethesda, Maryland: Marine Mammal Commission. 94-110. 3. Melnikov I.A., Zhitina L.S., Kolosova E.G. 2001. The Arctic Sea Ice Biological communities in recent environmental changes. In: Mem. Natl. Inst, Polar Res., Spec. Issue, 54: 409-416. 4. Melnikov I.F., Kolosova E.G. 2001. The Canada Basin zooplankton in recent environmental changes in the Arctic Ocean. In: Proceedings of the Arctic Regional Centre, v.3, 165-176. 5. Melnikov, I.A., L.G. Kolosova, H.E. Welch and L.S. Zhitina. 2002. Sea ice biological communities and nutrient dynamics in the Canadian Basin of the Arctic Ocean. Deep-Sea Research Part I, 49: 1623-1649.

B41A-02 0830h POSTER

Carbon Fluxes in Boreal Peatlands, La Grande Rivière Area, James Bay Lowlands, Québec, Canada

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As part of a large project on carbon dynamics in boreal peatlands, carbon dioxide and methane fluxes were measured in three peatlands in the La Grande Rivière area, James Bay lowland, Québec, Canada, between June and August 2003, and during one week in November 2003 and March 2004 (LG2 site only). The three sites studied correspond to the main peatland types present in the region (LG1, Rich Fen; LG2, Ombrotrophic Bog; LG3, Poor Fen). Measurements of CO_2 and CH_4 were made using static chambers on 20 collars in each peatland, 2 or 3 collars per ecological groups. A PP system infrared gas analyser was used for CO_2 measurements while CH_4 samples were analysed on a gas chromatograph. At each site, a weather station was installed to measure air temperature, relative humidity, precipitation, water table depth, PAR and peat temperature at 5, 10, 20 and 40cm depth. The objectives of this research are to determine the fluxes of CO_2 and CH_4 on the three sites and determine the relationships between the fluxes and water table depth, peat temperature and PAR obtained from the weather station. Preliminary results for CH_4 are between 1.43-120 mg m^{-2} d^{-1} (average 46.42 mg m^{-2} d^{-1}) for the LG1 site, 1.19-125 mg m^{-2} d^{-1} (average 39.69 mg m^{-2} d^{-1}) for the LG2 site and 2.68-300 mg m^{-2} d^{-1} (average 59.97 mg m^{-2} d^{-1}) for the LG3. There is a strong relationship between seasonal average water table depth and CH_4 flux.

B41A-03 0830h POSTER

Using In Situ Observations to Characterize Regional-Scale Patterns of Surface Albedo Across the North American Boreal Region

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The central role that land surface albedo plays in the physical climate system makes it a key component of climate and ecosystem models. However, this parameter remains one of the largest radiative uncertainties associated with modeling attempts. Uncertainty occurs because models commonly prescribe albedo using in situ observations, which are rarely sufficiently dense to accurately characterize albedo at a regional scale. This is especially problematic over seasonally snow-covered landscapes such as the boreal forest. The aims of this study are to (a) analyze and compare the local- and regional-scale albedo characteristics of the dominant land cover types found within the North American boreal region, (b) assess the the effects of snow cover on these patterns, and (c) quantify the potential bias that can result from using local-scale observations to describe surface albedos across larger geographical extents. Our study is based on local-scale in situ observations and regional-scale satellite (GOES) measurements that were collected as part of the Boreal Ecosystem-Atmosphere Study (BOREAS). Our results show (a) that the albedo patterns among land cover types are generally consistent at local and regional scales, (b) that snow cover not only increases the albedo of all cover types, but also their sensitivities to changes in solar zenith angle, and (c) that weekly-averaged in situ observations provide a reasonable characterization of regional-scale albedo when under snow-free conditions, but a poor characterization when snow is present. Land cover albedo characteristics are caused by canopy properties that influence within-canopy shadowing. The disparity between in situ albedo observations and those collected over low-density needleleaf forest are particularly a concern because this cover type comprises a significant proportion of the boreal region, and its misspecification in climate models could lead to large errors in energy balance. Further studies should focus on reducing the disparity between albedo datasets over snow-covered surfaces. They should also consider the effects of diffuse radiation, as well as finer time scales, on the above relationships.

B41A-04 0830h POSTER

Spatial Relationships in Local Net Ecosystem CO2 Exchange Among Representative Riparian and Land-use Types in a First Order, Agricultural Basin

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Recent studies have demonstrated the importance for quantifying CO2 exchange rates for all ecosystem components of the landscape. This work has shown that CO2 fluxes may be greater for relatively smaller land areas, such as riparian zones, and that their contribution to the total carbon (C) budget is substantially larger than previously expected. This potential source could be even greater for temperate riparian systems with shorter winter seasons and greater interseasonal variability. However, these previous investigations for temperate riparian areas are lacking due to logistical difficulties and time constraints of measuring distinct landscape units. This study was conducted the Strawberry Creek Watershed (SCW) a perennial, first order stream located in a small (3 km2) agricultural watershed in Maryhill, ON (15 km north of Waterloo, ON). The CO2 fluxes (NEE and respiration) were measured at least once a week from May 28 to September 11, 2003, using dynamic CO2 chambers and a portable Infa-red gas analyzer (IRGA). Simultaneously, climatic variables such as soil temperature, soil moisture and photosynthetically active radiation, and biotic factors, such as soil properties were evaluated. Further, to better understand the CO2 dynamics from field measurements, a lab incubation experiment was performed to assess the contribution of roots and soil towards the overall CO2 flux under varying soil temperature and moisture regimes. This paper illustrates the results of this study that aim to quantify and identify the growing season source/sink dynamics of various land-use types (riparian zones, open grassland fallow and maple woodlots) and their inherent environmental controls of surface (soil and vegetation) CO2 fluxes. Preliminary results suggest that soil temperature, at 5 cm depth, is the dominant mechanism controlling the temporal variability of CO2 emissions from both bare (belowground) and vegetated plots. However, this relationship seems to decouple during drought conditions. Furthermore, results indicate that long-term grass fallow sites may be substantial sources of carbon.

B41A-05 0830h POSTER

Relating Landscape, Vegetative, and Soil Characteristics With Net Nitrification Rates in Forested Watersheds

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Forested watersheds in the northeastern USA receiving similar levels of N deposition have exhibited different levels of stream nitrate export and different rates of soil nitrification. Recent isotope studies have demonstrated that stream water nitrate is isotopically similar to soil nitrate, suggesting that watershed soil nitrification rates directly influence watershed N loss. We are currently studying 10 watersheds in New Hampshire, New York, and Vermont in order to investigate correlations between watershed characteristics, soil properties, and soil nitrification rates. Watershed 24 hour nitrification rates seem to correlate well with stream nitrate export. Initial findings have shown positive relationships between higher nitrification rates and greater sugar maple abundance, low C:N, and lower amounts

of conifers. Initially, topographic characteristics do not appear to be as effective in predicting nitrification rates. We hope to identify watershed characteristics that explain the spatial variability of soil nitrification rates both within and between the study watersheds.

B41A-06 0830h POSTER

Measurement of Methane Precursor Compounds in Soil Porewater of Two Rice Cultivars Under Conditions of Natural Suppression of Methanogenesis

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Under identical growing conditions, rice cultivars have exhibited significantly different seasonal emissions of methane (CH_4), a greenhouse gas. Previous work on cultivar differences has focused primarily on determining the extent to which each methanogenic pathway, fermentation of acetate and reduction of carbon dioxide, contribute to methane production in the sediment of flooded paddy fields. In this study, amino acid and organic acid precursor compounds of methanogenesis were measured in soil porewater samples collected six times throughout the growing season from greenhouse plots of Mars and Lemont cultivars of rice and an unplanted plot. Samples were obtained by suction withdrawal of porewater from hydrophilic porous polymer tubes, of 0.10 micron diameter pore size, which remained permanently installed in growing plots throughout the experiment at 3, 10, 17 and 24 cm depths below the soil-water interface. In addition to analyzing porewater for acetate, alanine, and propionate, concentrations of dissolved methane and carbon dioxide were also determined. For much of the season, methane production was naturally suppressed by the reduction of iron (III), Fe^{3+}. Methane porewater concentrations of greater than 20 μM were not observed until 68 days after the plots were flooded and spectrophotometric analysis showed [Fe^{3+}] of > 2 μM until that time. In the absence of significant methanogenesis, measurements of methane precursors in situ provide an estimate of differences in root exudates with cultivar type.

B41A-07 0830h POSTER

Relationship Between Net Ecosystem Exchange, Methane Dynamics and Plant Growth in a California Rice Paddy.

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In wetland ecosystems (including rice paddies), positive correlations between CH_4 emission and net ecosystem exchange at certain times of the season ecosystems have been observed. In the case of rice paddies, attempts have been made to apply these stoichiometric relationships over annual time scales to derive regional or even global estimates of carbon sequestration from methane budgets. In this study, we measured net CO_2 exchange from a California rice paddy by eddy covariance for a period of 2.5 years. In the last year of the study, CH_4 flux was measured using both an intensive chamber sampling technique and a flux gradient technique using CO_2 as a tracer for diffusivity. Using these measurements, we were able to obtain a seasonal ratio of CO_2 exchange to CH_4 emission over a whole year. During the growing season, a strong correlation between net CO_2 exchange and CH_4 emission was observed with a stoichiometry of -1:24 (g CH_4-C / g CO_2-C) but over the whole year the stoichiometry was -1:12 (g CH_4-C / g CO_2-C). Biomass was not a strong predictor of CH_4 emissions during the growing season. During the year, almost all of the carbon fixed by the rice crop was either removed by harvesting the rice grain or lost via heterotrophic respiration over the fallow period. The paddy acted as a small net sink of C (-390 kg C ha^{-1}) in the first year of measurements and a small net source of C (270 kg C ha^{-1}) in the second year of measurements.

B41A-08 0830h POSTER

Soil fertility alters carbon dioxide flux from soil in monospecifc tree stands

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Globally, the flux of carbon dioxide from soils to the atmosphere (i.e. soil respiration) is approximately 10 times greater than from fossil fuel combustion. Despite the magnitude of this flux, there is still considerable uncertainty about the role of biotic interactions in mediating this flux. We sought to test the hypothesis that increases in soil fertility would decrease soil respiration if trees decrease belowground C allocation to roots and C flux to soil. We applied fertilizer for three years to replicate plots of sugar maple (Acer saccahrum) and northern red oak (Quercus rubra) at the Turkey Hill Plantations (TH) in Dryden, NY. After two years of fertilization, soil respiration did not differ between fertilized and control plots in plots of either species. By year three, however, soil respiration was lower in fertilized plots. Soil respiration in fertilized sugar maple plots was 22% and 25% lower than control plots in August and September. Soil respiration in fertilized red oak plots was 12% and 11% less than control plots in August and September. Decreased soil respiration in fertilized plots likely resulted from decreases in fine root biomass and soil microbial activity. In fertilized sugar maple plots root and microbial biomass were 37% and 49% less than controls. In fertilized red oak plots root and soil microbial biomass were 14% and 23% less than controls. These results suggest that factors which influence soil fertility in northeastern forests such as increased N deposition may decrease soil respiration if trees decrease belowground C fluxes.

B41A-09 0830h POSTER

The Nitrogen cycle, Nitrification and the Relationship with CO2 and O2 Exchange

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Human activities have had a major impact on the global carbon and nitrogen cycles. In contrast to studies of CO2 exchange, effective tools for the non-invasive measurements of N cycle transformations have not been developed and there is much to learn about the control of, and complex interactions associated with processes such as nitrification, denitrification and nitrate assimilation. Since N cycle transformations involve redox reactions, a theoretical model was developed to explore the potential for using the imbalance in measured CO2 and O2 exchange of biological systems as an indirect, non-invasive measure of nitrogen cycle transformations. For every mole of NH3 nitrified to NO3-, the model predicted that there would be 2 more moles of O2 taken up than CO2 produced by the same system that was not undergoing nitrification. To test this hypothesis, laboratory and field studies where carried out in which control and NH3-treated soils were continuously assayed for CO2 (Licor IRGA) and O2 (Qubit Systems Differential O2 Analyzer) exchange. The laboratory studies clearly showed that for about 3 weeks following soil treatment with NH3 (8.2 umol NH3/gDW soil, equivalent to 200 kg N/ha), CO2 production was suppressed by about 18%, and O2 uptake was stimulated by up to 251

B41A-10 0830h POSTER

Formation of Potholes by Surficial and Endolithic Bacteria on the Colorado Plateau Near Moab, Utah

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The area of the Colorado Plateau near Moab, Utah is home to an ecosystem delicately balanced on a substrate of Triassic and Jurassic aeolian sandstones with little to no soil. Any surface feature in which the limited precipitation can be captured helps sustain the desert life in this semi-arid environment. Naturally occurring "potholes" fulfill this function in certain sandstone surfaces. Potholes range in size from shallow depressions to large swimming-pool sized features that can retain water throughout most of the year. In this study we focused on circular potholes that showed no indication of joint control, and held 5 to 9 gallons of water. Their formation is controlled by three types of bacterial growth: 1)black biofilms that line each pothole, 2)bacteria in the accumulated bottom sediments of the potholes and 3)the ubiquitous cryptoendolithic cyanobacterial communities found centimetres beneath the surface of the host sandstone. On-site and in-lab water testing were conducted during the dry season with de-ionized water to quantify the of ion concentrations extracted from the rock as an estimate of the overall bacterial activity and to determine what in the arenitic quartz sandstones is providing sustenance to these communities. ICP-MS showed elevated Ca++ (up to 14 mg/L) and Si++ (up to 2 mg/L) ion concentrations indicating that the calcite cement as well as the quartz grains are being dissolved. Daily fluctuations in phosphate levels were also observed which correlate with on-site water monitoring that showed pronounced diurnal cycling of pH values, between pH 8 and 10, indicating biological activity. Further exploration was conducted using SEM studies identified thick biofilms coating the sandstone surface as well as large fungal populations. The electron microprobe was used to determine distributions of ions in feldspar grains across the grain profile in areas exposed to the biofilms to determine if any local leaching had occurred. Our investigations show that these communities of bacteria provide an interface between higher organisms and the sandstone substrate, acting as pioneer species enduring rock temperatures in excess of 50oC and waters that can reach pH 10 during the days. The cryptoendolithic bacteria in particular are insulated by the rock causing the temperature in the rock to be higher than in the surrounding air. In surviving these types of extreme conditions these bacteria suggest ways in which life may have colonized and left its mark on the early Martian surface.

B41A-11 0830h POSTER

Monitoring Algal Blooms in Inland Waters From Space-Borne Observation; A Case Study From Northern Africa, Lake Nasser

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A preliminary study was conducted to explore techniques and to develop and calibrate methodologies that combine inferences from field and remote sensing data to quantify temporal and spatial variations in lake physical parameters, and to examine their effects on primary productivity, and carbon sequestration rates in artificial lakes. The Case II waters of Lake Nasser (6000 km^2) in southern Egypt were used as a test site. The construction of the Aswan High Dam in the 1960's has had major impacts on the landscape in southern Egypt. It gave rise to Lake Nasser, an extensive (capacity: 1.6 x 10^{11} m^3, length: 500 km, average width: 12 km, average depth 30m) reservoir in southern Egypt and northern Sudan. In this study, we analyzed temporal (1980-2004) satellite images acquired over Lake Nasser to investigate spatial and temporal variations in aquatic parameters (e.g., chlorophyll and suspended matter) across the lake, and to test the usefulness of a variety of sensors and algorithms typically used for studies of larger water systems for this specific site. The investigated datasets include Moderate Resolution Imaging Spectroradiometer (MODIS), Sea-viewing Wide Field-of-view Sensor (SeaWiFS), and Coastal Zone Color Scanner (CZCS). The following patterns were identified. First, we detected a general enrichment in chlorophyll and in suspended matter upstream compared to the downstream and in the tributaries (Khors) compared to the main channel. This observation is consistent with the reported variations in sediment thickness along the length of the Lake. Thick deposits of up to 25 m were reported at the 2^{nd} Cataract some 350 km south of the Aswan High Dam compared to 1m thick deposits in the vicinity of the Dam. Second, we observed a general and progressive increase in suspended matter and chlorophyll content in the autumn consistent with patterns of annual flooding which carry excess silt, clay, and nutrients. Future work will focus on 1) characterizing trends in carbon sequestration in Lake Nasser over time and space, (2) investigating the nature of the particulate matter in the lake and the role played by in-lake processes in carbon sequestration, and (3) developing methodologies by which remote sensing data could be used to monitor and assess carbon sequestration in the Lake.

B41A-12 0830h POSTER

Comprehensive Two-Dimensional GC Analysis of Geological Samples Using Pyrolysis Inlet and Time-of-Flight MS Detection

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A pyrolysis inlet-comprehensive two-dimensional GC time-of-flight MS (Pyr-2DGC-TOFMS) system was used to study several groups of rock, soil, and tholin samples. Rock samples studied include limestone, gypsum, and basalt with varying particle sizes. Many different soil samples were studied from varying locations and under varying conditions. The tholins studied are a synthetic analogue to the solid organic materials that are responsible for the thick haze that surrounds Titan, the largest moon of Saturn, and are thought to have been present in the early Earth atmosphere. These mixtures represent a unique and complex application for 2DGC due to the high number of components with a wide range of volatility and polarity. In this study we use Pyr-2DGC-TOFMS to separate and characterize sample components. Using this chromatographic method, two capillary columns are connected in series with a thermal modulator at the junction point. The first column, a relatively long column with a non-polar stationary phase, is used to separate components based primarily on their boiling point. The second column, a short column with a polar stationary phase, allows for a quick separation based on polarity. A two-stage thermal modulator at the column junction point uses a liquid nitrogen-cooled jet to trap and focus components as they come off the first column and then injects them into the second column as a narrow plug using a hot air jet. The two-dimensional separation increases the chromatographic peak capacity and allows for increased sensitivity for trace components. The highly structured chromatograms provided by 2DGC allow for the prediction of peak locations in the retention plane and aid in peak identification. When coupled with a TOF-MS detector the 2DGC is a powerful tool for the separation and identification of the 1000+ peaks that are seen in these rock, soil, and tholin samples. Pyrolysis is the ideal sample introduction system for these samples since they contain high molecular weight compounds and are not soluble in most organic solvents. Information collected by these experiments will contribute to the analysis of pyrolysis and GC/MS data collected by the current Cassini-Huygens mission to Saturn and Titan that will reach its destination in the summer of 2004. In addition, this work will contribute to the instrumental and experimental designs for proposed instrument packages for future missions to the surface of Mars.

B41A-13 0830h POSTER

Basin-Scale Nitrogen Flux at the Stream-Soil Interface in the Rio Icacos, Puerto Rico.

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Studies at the plot and reach scale in the Rio Icacos, a small (3.2 km^2) tropical forest upland catchment, have shown that the riparian zone and streambed are areas of active nitrogen (N) processing and exert significant control over N flux into stream water. To test the validity of these results at the basin scale, we installed groundwater and streambed wells along the main stem of the Icacos . Chemical analyses were performed to determine inorganic N species and total organic N content of ground and stream water samples collected from July to August 2003 and January to February 2004. In addition, slug tests were performed in all wells to determine saturated hydraulic conductivity (k_{sat}), and bromide tracer additions were made along the main stem to determine groundwater discharge rates. These were used to calculate total N flux into the river and determine the significance of N uptake and loss at each site. Physical (k_{sat}) and chemical (redox potential) characteristics were then correlated with N concentration and uptake rates at each site. Initial results indicate that redox conditions are related to inorganic N speciation. This implies that riparian zones with strongly reduced groundwater may play an important role in controlling N flux into tropical streams.

B41A-14 0830h POSTER

New Production in the Northeastern Arabian Sea During Winter Bloom (February-March 2003)

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Arabian Sea has been centre of attention during Joint global Ocean Flux Study (JGOFS) due its uniqueness of strong seasonal oscillations of biological productivity. Different groups have studied the Northwestern Arabian Sea in order to understand its biogeochemistry with prime intention of characterizing Arabian Sea as source or sink of CO2. Northeastern Arabian Sea was studied by Indian JGOFS. However, the aspect of biogeochemistry which remained untouched during Indian JGOFS was estimation of new production in the northeastern Arabian Sea. New production is part of total production which is due to extraneous input of nutrients to the surface layer. Under steady state new production is equal to export production and hence gives an estimate of organic carbon going out of surface layer forming an important aspect of global carbon cycle. We report here the first measurements of 15N based new production (cf. Dugdale and Goering, 1967) for Indian side of the Arabian Sea during February-March 2003, measured onboard FORV Sagar Sampada. JGOFS protocol was followed and samples were analyzed for nitrogen isotopes using a Finnigan Delta Plus isotope ratio mass spectrometer. The error in PON measurement was found to be around 10% and error in 15N atom% measurement was less than 1% in the case of nitrate and urea while 3.5% in the case of Ammonia. The stations were chosen after analyzing the chlorophyll data of OCM IRS P4 in order to cover the different biogeochemical provinces. The study was conducted at five different stations. Entire euphotic depth was sampled for six different light levels. The column integrated new production expressed in terms of carbon, using Redfield ratio of 6.6, varied from 454 mgCm-2d-1 to 1846 mgCm-2d-1. During similar study done in January 2003, which is starting of the winter bloom in this region, the new production was found to vary from 82 to 337 mgC m-2d-1. This significant increase in the new production from January to March indicates the increase in availability of nutrients because of convective mixing due to winter cooling *Madhupratapetal.*, 1996.

B41A-15 0830h POSTER

Spatial And Temporal Variability Of Nitrous Oxide (N2O) Emissions From Fertilized Agricultural Fields

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The development of emission factors for N2O is complicated by its large spatial and temporal variability. Spatial variability may be due to effects of lateral water movements along different topographic gradients and temporal variability due to changes in temperature etc. over time. A field experiment was conducted in Ottawa, Ontario, to investigate the spatial and temporal variability of N2O emissions. Five sample sites within a transect east to west of the field, representative of the general topographic features of the entire field, were chosen for N2O sampling based on digital elevation maps (DEM). Surface flux chambers were placed at all sample sites to measure spatial variability. Simultaneously, flux towers connected in situ to a Tunable Diode Laser (TDL) in the field measured temporal N2O variability, using the gradient micrometeorological technique. Soil moisture and temperature were measured using time domain (TDR) probes and thermistors and supporting meteorogical data was obtained from a nearby meteorological station. Higher N2O emissions were observed from chambers at lower topographic positions, than those at the higher topographic positions at one event in the early spring period. Significant N2O emissions (500- 1000 ng m-2 s-1) were observed from the flux towers around early June however, surface chambers produced negligible emissions. This probably occurred because surface chambers were too site specific, therefore did not capture aggregated emissions. Results will be used to test the ecosys model to simulate N2O at site (chamber measurement) and landscape scales (micrometeorological measurements) using its unique 3-dimensional modeling capability. Input data for the model run will include a DEM of the field, measured soil properties and meteorological data as well as the land use management. Lateral water movement will be simulated to show spatial variability and later emissions will be aggregated to show temporal variability. Results may provide a methodology to scale N2O emissions from the site to landscape scale in order to make regional and then national predictions of N2O.

B41A-16 0830h POSTER

Modelling Landscape N_2O Emission of Agricultural Land by Integrating ECOSYS and GIS

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N2O emission is highly variable spatially and temporally, but current measurement methods cannot track these two variations simultaneously. An ecosystem model (ecosys) integrated with GIS provides an easy way to represent spatial and temporal variations of N2O emission over landscape. In the integrating environment, soil properties in meter-scale are estimated by landscape soil property predictors with 0.3 to 0.8 of independent test coefficient (R^2) between measured and estimated soil properties. These properties are used as input data to feed ecosys, a physical, chemical and biological process model. The temporal and spatial variations of N2O emissions are simulated based on the differences of water and nutrient content, and plant growth, and the exchange of water and nutrient over landscape. The coefficients (R^2) are 0.28 to 0.68 between measured and modelled N2O emissions at different landscape positions. Modelled N2O emissions mainly happened in spring and early summer, and were directly related to relative water-filled porosity. Spring fertilizers almost doubled N2O emission modeled in spring and early summer. Modelled annual N2O emissions vary from < 50 mg N.m-2 at summits and top slopes to 200 - 400 mg N.m-2 at middles slopes and saddles to >1500 mg N.m-2 at foot slopes and depressions. These differences were larger in a drier year. Modelled N2O emissions were reduced in chronically wet areas due to strong anaerobic conditions that forced N2O further to denitrify to N2.

B41A-17 0830h POSTER

Ecohydrological significance of observed power-law distributions of tree canopy cluster sizes for savanna vegetation

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Savanna ecosystems are characterized by sparse tree cover, the pattern of which can provide insight into the processes by which these systems are shaped and maintained. Since water is often considered to be the limiting factor for savanna vegetation, we used mean wet season rainfall (MWSR) as the basis for the selection of six sites along the Kalahari Transect, a north-south aridity gradient in southern Africa. MWSR ranged from 879 mm to 216 mm from the wettest to most arid site, and the corresponding fractional tree cover ranged from 0.65 to 0.04. IKONOS satellite images, having a resolution of 4m in the multi-spectral bands, were acquired for each of these sites and tree canopies were identified by merging the remotely-sensed normalized difference vegetation index data with information taken from ground-based surveys. Analysis of the tree canopy cluster size distributions showed the wettest site to deviate from a power-law distribution as a result of the fractional cover being above the four-neighbor percolation threshold for a square lattice. Four of the five other sites, however, were characterized by distinct power-law distributions, despite having substantially disparate fractional covers. Simple random neutral models were insufficient in describing the tree clustering patterns of the observed savanna landscape, leading us to seek fundamental interactions that could explain the consistent spatial organization. In particular, our cellular automata approach focuses on water use by the savanna vegetation, and how annual variability in this

limiting resource can lead to emergent pattern formation.

B41A-18 0830h POSTER

Feasible optimality of vegetation patterns in river basins

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We examine the mechanisms leading to the maintenance of organized vegetation patterns within the network structure of a semiarid New Mexico river basin due to the controlling influence of water stress. A recently formulated analytical framework for the water balance at the daily level is used to link the distribution of climate, soils and vegetation within the basin to patterns growing season water stress. We compare the actual patterns of water stress within the basin to the distribution of water stress that results from vegetation patterns distributed according to two algorithms of local optimization. We demonstrate that a model which maintains local optimization within the network flow path exhibits a better agreement with the patterns of actual basin water stress than a model that allows for neutral local interactions that ignore the network structure of the river basin. These results suggest that the pattern of actual vegetation observed within the basin may correspond to a condition of feasible optimality in which large-scale organization is constrained by the stochastic nature of local interactions mediated by the network configuration. The principles of such organization have important consequences regarding the impact of land cover change on hydrological dynamics in river basins, as well as the geomorphological and biogeographical evolution of landscapes under varying climate and disturbance regimes.

B41A-19 0830h POSTER

Nitrogen Removal by the River Network of the 400 km^2 Ipswich R. Watershed, MA, USA

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The importance of river networks in controlling exports of dissolved inorganic nitrogen (DIN) from large watersheds is an important yet unresolved question. We investigated the ability of the river network of the Ipswich R. watershed ($\bar{4}00$ km^2) to reduce DIN exports during a warm, low flow period (September 2000) and a cold, high flow period (December 2002). We used a GIS-based approach that coupled estimates of spatially distributed loading to the aquatic system, a digital river network (120m resolution), and observed fluxes hierarchically distributed throughout the river network. Spatially distributed loading was based on empirical DIN concentration vs. land use relationships developed from headwater sites, and estimates of runoff based on USGS gage and water withdrawal data. We estimated percent N removal for each time period by comparing predicted fluxes based on conservative mixing of loads and observed fluxes. We also compared observed N fluxes with predictions based on a regression model of % N removal vs. hydraulic load described in the literature. DIN loading concentrations were a function of urban and wetland land use, population density on septic systems, and surficial geology (adjusted R^2 = 0.54 in September 2000 and 0.71 in December 2002). Total DIN loading to the aquatic network was 35 kg/d in September and 490 kg/d in December. During September, the river network removed 31% of estimated DIN loading to the aquatic network. Much of the N removal occurred in the tributaries prior to reaching the Ipswich mainstem. In contrast, DIN behaved conservatively during December 2002 (0% removal). The N removal model predicted 66% and 10% N removal for September 2000 and December 2002, respectively. The model therefore over-predicted N removal but did capture temporal variation in retention strength resulting from changes in hydraulic loads. These results suggest that the river network can control watershed-scale DIN exports during the low flow growing season, but is less able to do so during high flow periods cold periods when most material fluxes occur.

B41A-20 0830h POSTER

Evaluating the Evidence for Potassium Co-limitation in Forested Ecosystems.

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Potassium is recognized as the most required element for maintenance and growth of plants after nitrogen. Relative to the elements nitrogen and phosphorus, the biotic cycling of potassium (K) has been relatively understudied in ecosystem ecology, possibly due to its lack of a discrete organic phase. We conducted a literature review to: (1) examine the potential of K to influence growth and physiological responses of forest tree species (2) compare relationships between the export of K and NO_3-N in watersheds across different forest types, and (3) examine the influence of runoff on the export of K, NO_3-N, and other base cations. We identified thirty-seven studies that reported the effects of K fertilization on tree growth and/or plant physiology in forested ecosystems. Thirteen out of the eighteen studies examining tree growth showed significant increases in biomass following additions of K. Twenty-three out of the twenty-six studies examining nutrient status in plant tissue showed significant increases in K concentration. Seven out of eleven studies, that simultaneously reported concentrations of K, N, Ca, and Mg in stream water from temperate and tropical watersheds, indicated a significant linear relationship (Pearson r^2 = 0.44-0.99) between intraannual concentrations of K and NO_3. On a seasonal basis, concentrations of K in stream water generally followed a similar seasonal pattern to N, which has been widely accepted as the primary limiting nutrient in forest ecosystems. In contrast, concentrations of calcium and magnesium did not show significant relationships with nitrate. Instead, concentrations of these other base cations appeared to be related to seasonal variations in discharge. The combined evidence from fertilization and watershed output studies suggests that K has the potential to be in biotic demand as a co-limiting nutrient in forested ecosystems. Yet, the significance of potassium and how its role may change in response to various anthropogenic disturbances remains to be clarified in ecological research.

B41A-21 0830h POSTER

Characterization of Surface Spatial Heterogeneity for Scaling Non Linear Processes

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The monitoring of earth surface dynamic processes at global scale, such as primary production, carbon and water fluxes, requires high temporal frequency remote sensing observations. Because of technological constraints, the sensors are characterized by coarse spatial resolution, i.e. a resolution from few hundred meters (MERIS/ENVISAT, MODIS/TERRA) up to one or few kilometres (VEGETATION/SPOT, SEVIRI/MSG). At these scales, the spatial heterogeneity of the observed scenes together with the non linearity of the transfer function relating the biophysical variable of interest to the radiometric data, generate a bias in the estimation of this variable. The aim of this study is to quantify the spatial heterogeneity to correct the biophysical variable estimation bias at coarse spatial resolution. The NDVI vegetation index of high spatial resolution images (SPOT 20m) is used to characterize the ground spatial structure of various landscapes. These NDVI images are then aggregated in order to describe the evolution of their structure with the spatial resolution. The variogram function is chosen to model the spatial distribution of different scenes as well as to quantify the spatial heterogeneity as a function of the spatial resolution. An analytical model of the estimation bias is built: it is a function of both the spatial heterogeneity characterized by the variogram and the degree of non linearity of the transfer function. First a univariate formulation of the analytical model is applied to an empirical transfer function between LAI and NDVI. Preliminary results show that the model is efficient to correct the bias for highly heterogeneous landscapes and for a range of coarse spatial resolution larger than 300m. To account for the availability of multiple wavebands, a multivariate description of the spatial heterogeneity is used. It allows to apply the analytical model on different types of transfer functions. The main limit of the analytical model lies in the availability of variogram information over the region of interest. The temporal stationarity of the variogram is studied to determine the relevance of the method within an operational context. Finally, the results of this study are discussed in order to define an optimal spatial resolution for future monitoring missions. Key Words: biophysical variable estimate, remote sensing, spatial heterogeneity, non linear process, scaling, spatial resolution, variogram.

B41A-22 0830h POSTER

Alteration of Nontronite NAU-2 by a Sulfate-Reducing Bacterium

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Iron-rich clay minerals are abundant in the natural environment. The goal of this study is to understand the mechanisms of enhanced reduction of Fe(III) in Fe-rich clay minerals under sulfate-reducing conditions. In particular, biogenic reduction of the structural Fe(III) and release of other elements in a nontronite sample (NAu-2) are studied using a Desulfovibrio spp. strain G-11 with or without amended sulfate. The microbial production of Fe(II) from NAu-2 was about 10% of total structural Fe(III) (30 mM) when Fe(III) was available as the sole electron acceptor. The production of Fe(II), however, reached 29% of total structural Fe(III) when both Fe(III) and SO4= (50 mM) were concurrently used as the electron acceptors. Abiotic production of Fe(II) from reaction of NAu-2 with Na2S (50 mM), on the other hand, was only ca. 7.5% of total structural Fe(III). The enhanced reduction of structural Fe(III) by G-11, particularly in the presence of sulfate, is directly related to the growth rate and metabolic activities of the bacteria which results in destruction of the structure of the nontronite. Analyses by SEM, TEM, XRD, and EDS revealed significant changes in the structure and composition of NAu-2 during its alteration by bacterial sulfate reduction. G-11 could also derive nutrients from NAu-2 to support its growth in the absence of amended minerals and vitamins. Results of this study suggest that sulfate-reducing bacteria may play a more significant role in cycling of Fe, S, and other elements during alteration of Fe-rich clay minerals and other silicate minerals than previously recognized.

B41A-23 0830h POSTER

Oxygen: Key for Life but Enemy of the History of Life.

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Skeletal carbonate is our primary source of paleobiological information, and the primary means by which carbon is transferred from the atmosphere-ocean to the lithosphere. As such, processes which control its preservation and fidelity are of primary importance to interpreting the fossil record and the carbon cycle. Implicit in any examination of biological remains is the understanding that some parts of the original animal are modified or missing. The explicit study of the process of post-mortem preservation (taphonomy) has now amassed sufficient breadth that we can start to examine broad scale patterns in the record, or megabiases. To date there has not been much explicit focus on the role of biological interactions with the skeletal remains as a means of destroying those remains on the scale of the fossil record. Here an examination of marine skeletal carbonate across tropical and temperate latitudes, in environments ranging from vibrant reefs to hypoxic fjords, reveals a pattern of skeletal modification that correlates with the overall diversity and

density of the community. The more diverse and heterogeneous an ecosystem, the more modified the biological remains will be. From a reductionist perspective, this could be simplified to the quality of the fossil record is inversely related to the amount of oxygen available in the environment. It has long been understood that permanent smothering/removal of oxygen/burial is an effective way of preserving biological remains. This is for two reasons: a) microbes oxidizing any available organic carbon are limited to using electron acceptors other than oxygen, at a loss of energetic return, and b) multicellular animals that would exploit the food source or substrate require oxygen for their own metabolisms, therefore if the remains are removed from oxygen they are physiologically not accessible. This intuition has developed in terms of soft tissue remains, and in complete absence of oxygen. However, the natural world is a complex of environmental gradients, with oxygen and other essential parameters varying among environments. As a function of physiological limits, environments vary in the density and diversity of biota that they contain. Biological remains are part of the resources of an ecosystem with tissues as sources of organic carbon, skeletons as potential substrates and eventually as chemical ions (particularly in marine settings). So, the more healthy the community, the more they are busy recycling and obliterating any record of previous generations/communities. Similarly, for carbonate burial, regions of the highest carbonate production are likely also regions of the highest carbonate recycling. Lest this be taken as an excuse to dismiss the fossil record as biased, we would no more think of doing so than with historical or archeological records, despite the fact that those preferentially record histories of the victors, the wealthy, and the literate. Just as we look beyond well preserved accounts of life at a monastery for clues of life in urban medieval Europe, so should we look beyond well preserved fossils to glean what paleo-biological and environmental clues we can from less than beautifully preserved fossils and the sediments that contain them.

B41A-24 0830h POSTER

Exploring Quantitative Wetlands Mapping Using Airborne Lidar and Electromagnetic Induction on Mustang Island, Texas

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We combine elevation data acquired using airborne Lidar, conductivity measured using ground-based electromagnetic (EM) induction, and vegetation surveys to examine whether topography and ground conductivity can be used to map coastal wetland vegetation assemblages. In 2003, we acquired elevation data along two transects across Mustang Island, a modern coastal barrier on the central Texas coast. We combined the cm-scale elevations with conductivity measurements and vegetation surveys acquired at 20-m spacings from the gulf beach to the bay shore. Wetland vegetation responds to both elevation and salinity; because ground conductivity is strongly influenced by soil salinity, we used EM induction measurements as a salinity proxy. Elevation and conductivity information, acquired either on the ground or from aircraft, represent a quantitative complement to traditional wetland mapping methods that rely upon aerial photographs. Along both transects, conductivities were negatively correlated with elevations. Highest average conductivities (1565 to 1745 mS/m) were measured on wind-tidal flats (elevation -0.05 to 0.5 m NAVD). Salt marshes at elevations of -0.1 to 0.3 m (low) and 0.2 to 0.8 m (high) had lower average conductivities of 1270 to 1365 mS/m (low marsh) and 805 to 868 mS/m (high marsh). We measured relatively low average conductivities of 92 to 223 mS/m in low and high fresh marshes at elevations of 0.5 to 3.1 m. Dunes and vegetated barrier flats with elevations as high as 7.5 m NAVD had the lowest conductivities of 12 to 96 mS/m. Combined or alone, elevation and conductivity data allow better discrimination among coastal wetland environments than can be achieved from aerial photographic interpretation.

B41A-25 0830h POSTER

Colloidal Iron is Bioavailable to Phytoplankton Communities in the North Pacific and Bering Sea

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Biological productivity in the HNLC regions of the oceans is limited by the availability of Fe. In such regions, colloidal Fe could play an important role in relieving Fe-stress, although the bioavailability of Fe in natural marine colloids has not been investigated for in-situ phytoplankton communities. In order to test the bioavailability of marine deep-sea colloidal Fe, we performed incubation experiments in the HNLC North Pacific (47.0N, 170.0E) and Bering Sea (55.3N, 176.5E). Surface water at these sites was mixed with deep water (1000-1500m) from the same location and phytoplankton growth was monitored by Chl a concentrations. Some deep waters were filtered to remove only particulate (>0.4 mm) material, while others were filtered to remove both particulate and colloidal (>0.02 mm) material. Both types of filtered deep water consistently stimulated phytoplankton growth compared to control incubations of surface water only. High concentrations of major nutrients (eg. N, P, Si) in the deep ocean and soluble (<0.02 um) Fe are of course responsible for growth enhancement. When both soluble and colloidal iron were present, Chl a increases were greater (380-450%) than in the experiments where deep water with only soluble nutrients was added (310-325%). We hypothesize that the growth-enhancing factor in deep-sea marine colloids is bioavailable Fe. Dissolved Fe concentrations in surface waters at the experiment sites was relatively low (0.3-0.35 nmol/kg). When deep water was mixed with surface waters, soluble Fe was calculated to increase the total dissolved Fe concentration by 0.3-0.65 nmol/kg, and colloidal Fe was calculated to add another 0.09-0.12 nmol/kg Fe. By the end of the incubation period, total dissolved Fe concentrations in all experiments had decreased by 30-60% as a result of biological uptake. This is the first report of enhanced phytoplankton growth resulting directly from the biological uptake of colloidal Fe.

B41A-26 0830h POSTER

Microbial evidence for sulfur cycling in the deep subsurface of the Witwatersrand Basin, South Africa

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The continental deep subsurface harbors a heterogeneous community of microorganisms that have yet to be well understood. The gold mines of the Witwatersrand Basin in South Africa provide relatively easy access to this environment and have been integral to recent attempts to characterize subsurface microbiology. Molecular evidence for the biogeochemical cycling of sulfur has been detected in fissure water from Merriespruit and Driefontein mines. PCR amplification, cloning, and sequencing of adenosine-5'-phosphosulfate reductase (APS) and 16S rRNA genes were used to assess the composition of sulfur metabolizing microbial populations. Sequences closely related to APS reductase genes of the sulfur-oxidizing bacterium Allochromatium vinosum were detected in the Merriespruit Mine sample. APS reductase gene libraries from the Driefontein Mine sample were dominated by sequences with high identity to known sulfate-reducing bacteria. Phylogenetic analyses of 16S rRNA sequences indicated the presence of Thiobacillus-related species (known S-oxidizing organisms) in the Merriespruit sample, while Driefontein 16S rRNA clone libraries were dominated by sequences with high identity to known sulfate-reducing organisms in the delta-Proteobacteria and Firmicutes lineages. This study provides some of the first environmental APS sequences from sulfur-oxidizing bacteria and sheds new light on the organisms participating in sulfur-cycling in the deep subsurface.

B41B CC: 524 A Thursday 0830h

Isotopes in Biogeochemistry: The Atmosphere and Aquatic Environments

Presiding: **S Trumbore,** University of California, Irvine**; S Macko,** University of Virginia

B41B-01 0840h

A record of global photosynthesis to 150ka derived from the triple isotopes of O_2 in polar ice cores

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Records of the global rate of photosynthesis have the potential to reveal the nature of large scale interactions between biology, biogeochemistry and climate. Following Blunier et al [Global Biogeochemical Cycles 16(3) 2002] we have developed a 150ka record of the global rate of photosynthesis using the ^{16}O, ^{17}O, and ^{18}O content of O_2 in air bubbles in Greenland and Antarctic ice sheets. Our approach takes advantage of mass independent effects in the isotopic composition of O_2. These effects arise from stratospheric exchange reactions between O_3, CO_2 and O_2 that cause the $\delta^{17}O$ and $\delta^{18}O$ of O_2 to decrease equally, rather than by the common, "mass dependent" factor of 0.5. The magnitude of the mass-independent anomaly ($^{17}\Delta \sim \delta^{17}O - 0.5^* \delta^{18}O$) depends on the relative rates of stratospheric reactions and biological cycling by photosynthesis and respiration. We have made a preliminary calculation of past rates of photosynthesis by correcting for past atmospheric CO_2 concentrations (higher CO_2 promotes stratospheric exchange and enhances the anomaly) and for changes of biological isotope effects associated with shifts in the C3/C4 composition of plants. The paleoproductivity record reveals that global photosynthesis was within $\pm$ 5% of the modern rate during glacial periods and that it was higher than Holocene levels by as much as 10% during the Eemian (last interglacial). We found no statistically significant variability in paleoproductivity at orbital frequencies of precession or tilt during our study period. These conclusions are provisional and may be modified as more is learned about triple isotope fractionation during evapotranspiration and the secondary processes of O_2 consumption.

B41B-02 0855h

Isotopic diagnosis of processes governing interannual variability of $CO^{18}O$ fluxes in the tropics

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Large scale variations in precipitation and temperature in phase with ENSO dominate the interannual variability in gross primary production in the tropics. During El Nino periods, large areas of tropical ecosystems are subject to water limitation and reduction in gross primary production. Because the ^{18}O content of atmospheric CO_2 reflects a balance between gross