B42A-0943 1330h POSTER

Land Use Land Cover Change in the Albertine Region of Uganda

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Monitoring threats to protected areas and species is a major challenge for the conservation community. The Albertine Rift region is a hot spot of biodiversity with many endemic vertebrates and plant species. Most of forests east of the Albertine (Uganda, Rwanda and Burundi) are, however, highly fragmented and human population densities are some of the highest of Africa. In this study, we used a series of Landsat images to provide a quantitative assessment of forest loss between the 1980s to year 2000 for the protected areas in the Western Uganda. In this region, monitoring forest conversion to agricultural land and modeling future threats for the protected areas system are important to the maintenance of wildlife populations. By combining remote sensing monitoring techniques with traditional field surveys, it becomes easier to monitor and manage extensive protected area systems. Most of the forest loss (deforestation) was located outside the official protected area limits, indicating that active deforestation during this period is mainly located on non protected lands. The largest forest loss was located in the north around Bugoma, Budonga and Kagombe Forest Reserves and is associated with large scale farming and mechanized logging.

B42A-0944 1330h POSTER

Preliminary Net Carbon Exchange Measurements in the Nebraska Sand Hills

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The Nebraska Sand Hills are the largest stabilized dune field in the world; they cover more than 50,000 square kilometers. The native vegetation is classified as a mixed grass prairie and the most common land use is cattle grazing. The proximity of the High Plains Aquifer to the land surface in this area gives rise to areas of abundant soil moisture in the generally semi-arid climate. This leads to an uncoupling of vegetation dynamics (including net carbon exchange) and recent precipitation in much of the region. We will present preliminary results of net ecosystem carbon exchange from eddy covariance measurements and soil surface carbon dioxide fluxes determined using a chamber technique. Fluxes will be examined in terms of relevant environmental and biological paramenters.

B42A-0945 1330h POSTER

Process Based Belowground Carbon Dioxide Modeling in a Desert Ecosystem

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We describe a study to integrate and assess biological and physical processes that govern belowground carbon dioxide levels at a semi-arid grassland near Canyonlands National Park. Carbon dioxide concentrations were measured every 30 minutes at 5 and 15 cm depth within the rooting zones of the two dominant grass species, Stipa hymenoides and Hilaria jamesii, as well as the interspace between the two. For Stipa hymenoides at 5 cm, a rain event caused belowground carbon dioxide levels to rise from 600 ppm to 2000 ppm with a response time of 8 hours, with a gradual return to quasi-steady state levels in subsequent days. A similar response was observed for H. jamesii. We developed and simulated a one-dimensional diffusion model with a production term for various types of CO_2 production from the literature (either constant with increasing depth or a process based source). The process based production considered microbial and root respiration as well as the temperature dependence of soil respiration. Model inputs included volumetric soil water content, temperature and bulk density. Incorporating a process based production term led to high correlation between measured and modeled CO_2 concentrations (r^2 as high as 0.92). Our results indicate that carbon dioxide levels increased during rain events due to physical (not biological) processes as the soil saturated with water, and CO_2 molecules diffused more slowly from the soil.

B42A-0946 1330h POSTER

Quantifying the Uncertainties in the Carbon Content of the Terrestrial Biosphere

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According to the IPCC (2001), the 1980s estimates for all major terms in the global carbon budget are subject to uncertainties. However, uncertainties in land use changes and terrestrial sinks are the largest, up to 200%. Here, we quantify the uncertainties in regional land use emissions as well as net terrestrial flux over the period 1765-2000. Using the terrestrial carbon cycle component of the Integrated Science Assessment Model (ISAM) coupled with observed atmospheric CO2, temperature and precipitation data, the effects of different land cover data sets on the response of plant and soil carbon stocks are assessed. This geographically-explicit implementation of ISAM simulates the carbon fluxes to and from different compartments of the terrestrial biosphere with 0.5-by-0.5 degree spatial resolution. Each grid cell contains at least one of the thirteen land coverage classifications, which represent both highly managed land uses and less managed biomes. Changes in the areal extent of land cover classifications are driven by shifts in land use related to agriculture, afforestation, deforestation, and reforestation. Within each grid cell and land-coverage classification, the modeled carbon cycle includes feedback processes such as CO2 fertilization and temperature effects on photosynthesis, and respiration. ISAM model simulations indicate that uncertainties in net terrestrial fluxes during the 1980s is mainly due to the large uncertainties in land cover change data for tropical Africa and south and south east Asia.

B42B MCC: 3014 Thursday 1340h

Estimating Terrestrial Carbon, Water, and Energy Fluxes From Site to Region I *(joint with A, H)*

Presiding: **J Styles,** Oregon State University**; K J Davis,** Pennsylvania State University

B42B-01 1340h

Estimates of ABL-scale net carbon dioxide flux in Central Wisconsin

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The atmospheric boundary layer (ABL) is a distinct air mass separated from the free troposphere by a density inversion. The exchanges of sensible heat, water vapor and trace gases which occur at the land surface influence the properties of ABL air. While most studies of the ABL have focused on the dynamics of the diurnal cycle of ABL depth and on changes in trace gas concentration that occur over this time frame, it should be noted that the ABL can persist as a coherent structure over several days. Betts and Ridgeway (1989) and Betts (2000) proposed that the ABL during a sequence of fair weather days can be viewed as a steady-state structure forced on the one hand by surface exchanges and on the other by atmospheric subsidence coupled to the large-scale energy balance of the troposphere. Surface modified air in the ABL is replaced by air descending from areas of subsidence or high pressure, and this flow diverges to areas with storm activity. Given sufficient time, an equilibrium may establish such that the transport of flux by divergent flow balances the surface exchange fluxes. Under these conditions the flux of any trace gas, F_x is, $F_x = -\Delta X \times W$ where ΔX is the change in mixing ratio of X in the ABL relative to the free troposphere and W is the mean vertical velocity through the top of the ABL. We are specifically interested in using this relationship to calculate net carbon dioxide flux over the area of integration of the ABL from measurements of carbon dioxide mixing ratio made from a tall towers (that sample the ABL) and aircraft measurements (that sample the free troposphere). We describe two independent methods for resolving W at these temporal and spatial scales and show how these estimates, along with measurements of carbon dioxide gradients, can be used to estimate ABL-scale net carbon dioxide flux. Our estimates agree well with eddy-covariance based estimates of regional flux over monthly to annual periods.

B42B-02 1355h

Regional CO_2 Fluxes Using a Network of Carbon Dioxide Mixing Ratio Sensors

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Inverse studies of CO_2 mixing ratio are traditionally conducted at coarse spatial and temporal resolution. This limits our ability to evaluate efforts to upscale chamber and stand level CO_2 flux measurements to regional scales, where coherent climate and ecosystem mechanisms govern the carbon cycle. We present an effort to implement atmospheric budget or inversion methodology on a regional scale. A first step towards this end is the evaluation of a network of six relatively inexpensive CO_2 mixing ratio measurement systems deployed on towers in northern Wisconsin as part of the Chequamegon Ecosystem-Atmosphere Study. Five systems are distributed on a circle of roughly 150-km radius, while one system is centrally located. All measurements are taken at a height of 76 m. The systems use LiCor-820 infrared CO_2 analyzers and are calibrated every two hours using four samples known to within $\pm$ 0.05 ppm CO_2. Field tests prior to deployment in which the six systems sampled the same air indicate agreement of the systems to within 0.5–1.0 ppm from the mean during relatively quiescent periods. Tests using tanks containing known CO_2 concentrations exhibit standard deviations of 1.0 ppm or less. If network precision and accuracy prove to be sufficiently high, these data will detect horizontal gradients in CO_2 mixing ratios caused by net ecosystem-atmosphere exchange. These horizontal gradients will be the basis for using atmospheric budget methods to derive regional fluxes with spatial and temporal resolution fine enough to warrant comparison to the ChEAS regional flux tower network. Results from the deployment (July–October 2003) are presented.

B42B-03 1415h

Airborne Flask Measurements of O_2/N_2, Ar/N_2, CO_2 and Other Species During COBRA-NA 2003

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We present measurements of O_2/N_2, Ar/N_2, CO_2, CH_4, CO, N_2O, H_2, SF_6, and $\delta^{13}C$ and $\delta^{18}O$ of CO_2 in airborne flask samples collected during the CO_2 Budget and Regional Airborne Study, which was conducted in North America over late May and June 2003 to develop methods of observing and modeling large scale fluxes of CO_2 and other atmospheric gases. Performed on the University of North Dakota Cessna Citation II, the campaign consisted of two circuits around North America, including regional flights over Harvard Forest, ARM-CART, and coastal areas of Northern California, Maine and Texas. The data from 350 sampled flasks will be interpreted for regional-scale surface fluxes of these species and as tracers to separate terrestrial, industrial, biomass-burning and oceanic contributions to variations and fluxes of CO_2 and CO. In addition, the understanding of vertical and horizontal transport and mixing of various flux signals that is enabled by our measurements is critical to scaling-up surface and airborne CO_2 flux measurements to basin scale.

B42B-04 1430h

Interpreting concentration measurements at flux towers

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The FLUXNET network contains nearly 200 sites around the world measuring carbon, water and energy fluxes by the eddy covariance method. Concentrations are also measured at these sites, usually only as a by-product. We show that the diurnal pattern in CO_2 concentrations measured at flux tower sites can be interpreted within a simple atmospheric boundary layer model framework to predict surface CO_2 flux. Concentration measurements have a much larger footprint than flux measurements, so this method can provide estimates of regional fluxes. In combination with remote sensing data to assess spatial heterogeneity, a network of sites could provide continental-scale flux estimates. We apply this idea to forest flux tower sites in the contiguous USA within the Ameriflux network.

B42B-05 1450h

Estimation of CO2 exchange at regional scales using spatial correlations of flux fields

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At regional to continental scales (> 1000 km), measurements obtained by eddy covariance flux towers are essentially samples at individual points within a flux field. A challenge is to estimate total flux exchange over this field from a limited number of sampling observations. This difficult task can be achieved by combining eddy covariance flux observations with spatial correlation structures of the flux field. It is well known that environmental conditions at different locations of a region are correlated. Remote sensing of gross primary production and net primary production also shows distinctive and coherent spatial structures. Therefore it is not surprising that CO2 flux exchanges at different locations of a region are correlated (either positively or negatively). This correlation provides powerful constraint for regional flux integration. Here a mathematical framework for conducting this integration is outlined. A preliminary analysis of statistical structures of flux fields based on MODIS products is presented. Directions for further research are suggested.

B42B-06 1505h

Inferring Terrestrial CO_2 Fluxes From A Global-Scale Carbon Cycle Data Assimilation System (CCDAS)

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Various indirect methods suggest that much of the year-year variability in the growth-rate of atmospheric CO_2 over the last two decades is attributable to variability in the net terrestrial flux. It is much less clear which processes are responsible for this terrestrial variability. In this talk we present results from a carbon cycle data assimilation system (CCDAS) in which the controlling parameters in a terrestrial carbon cycle model are inferred by nonlinear optimization based on the model's adjoint. Uncertainties in the parameters are inferred from observational and model uncertainties via the model's Hessian and then mapped forward on predicted quantities such as net CO_2 fluxes to the atmosphere via the model's Jacobian. The adjoint, Hessian, and Jacobian are generated by automatic differentiation of the model's source code. The dataset is the set of extended CO_2 concentration records from 41 observing sites. The model is able to fit the observations moderately well although it slightly overpredicts the long-term growth rate. This occurs despite the increase in terrestrial uptake through the 1990s over the 1980s. The increase, in turn, occurs despite a reduction in net primary productivity and is hence caused by a larger decrease in soil respiration. It appears that the requirement to fit both the seasonal cycle and interannual dynamics in the CO_2 record is a strong constraint on model formulation. We will demonstrate this by describing some of the problems with the description of respiration which are highlighted by this approach.

B42B-07 1525h

Spatial Coherence of NEE Response of Different Ecosystems to the Same Climate Anomaly

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The onset of spring in 1998 was early in a large part of boreal, north central, and north eastern temperate North America. Here we compare forest ecosystem responses at several flux towers within the climate anomaly footprint. Measurements at four of these sites include both eddy covariance flux and well-calibrated carbon dioxide mixing ratio time series. The climate anomaly area is characterized by +2-4C mean temperature difference and about 50g C more uptake in spring of 1998 compared to the same period in 1997. A similar pattern of earlier uptake of carbon dioxide can be seen in the mid-day carbon dioxide mixing ratio time series. Using the global carbon dioxide mixing ratio measurement network and very simple transport assumptions, spring Northern Hemisphere carbon dioxide draw down is compared for the two years and seen to be qualitatively consistent with the local flux tower evidence. This research approaches the question of how large a land response must be, both in magnitude and area, to be detected by the global measurement network. This research also directly links the global flask network to the network of eddy-covariance flux towers. An extended network of coupled continental carbon dioxide flux and mixing ratio observations could be used to improve the accuracy of inversion-based estimates of net ecosystem exchange (NEE) of carbon dioxide.

B42C MCC: 3010 Thursday 1340h

Aqueous Microbial Geochemistry II

(joint with H, OS, V)

Presiding: **E Shock ,** Arizona State University**; L A Warren,** School of Geography and Geology, McMaster University

B

B42C-01 1340h INVITED

Thermodynamic Versus Surface Area Control of Microbial Fe(III) Oxide Reduction Kinetics

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Recent experimental studies of synthetic and natural Fe(III) oxide reduction permit development of conceptual and quantitative models of enzymatic Fe(III) oxide reduction at circumneutral pH that can be compared to and contrasted with established models of abiotic mineral dissolution. The findings collectively support a model for controls on enzymatic reduction that differs fundamentally from those applied to abiotic reductive dissolution as a result of two basic phenomena: (1) the relatively minor influence of oxide mineralogical and thermodynamic properties on surface area-normalized rates of enzymatic reduction compared to abiotic reductive dissolution; and (2) the major limitation which sorption and/or surface precipitation of biogenic Fe(II) on residual oxide and Fe(III)-reducing bacterial cell surfaces poses to enzymatic electron transfer in the presence of excess electron donor. Parallel studies with two major Fe(III)-reducing bacteria genera (Shewanella and Geobacter) lead to common conclusions regarding the importance of these phenomena in regulating the rate and long-term extent of Fe(III) oxide reduction. Although the extent to which these phenomena can be traced to underlying kinetic vs. thermodynamic effects cannot be resolved with current information, models in which rates of enzymatic reduction are limited kinetically by the abundance of "available" oxide surface sites (as controlled by oxide surface area and the abundance of surface-bound Fe(II)) provide an adequate macroscopic description of controls on the initial rate and long-term extent of oxide reduction. In some instances, thermodynamic limitation posed by the accumulation of aqueous reaction end-products (i.e. Fe(II) and alkalinity) must also be invoked to explain observed long-term patterns of reduction. In addition, the abundance of Fe(III)-reducing microorganisms plays an important role in governing rates of reduction and needs to be considered in models of Fe(III) reduction in nonsteady-state systems, e.g. subsurface environments in which Fe(III) reduction is stimulated by contamination with organics or for the purposes of metal/radionuclide bioremediation.

B42C-02 1355h

Evidence for the Occurrence of Microbial Iron Reduction in Bulk Aerobic Unsaturated Sediments

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Radionuclide transport experiments conducted in a large, meso-scale column reactor (MSCR, 10 ft high