products in the immediate vicinity of the flux tower are subsetted and posted on the FLUXNET Web site for 169 flux-towers. The MODIS subsets are prepared in ASCII format for 8-day periods for an area 7 x 7 km around the tower.

URL: http://daac.ornl.gov/fluxnet/

B51D-1001 0830h POSTER

Carbon and Water Exchanges in a Chronosequence of Temperate White Pine Forest

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Quantification of carbon sink or source strengths of temperate forest ecosystems, growing in northern midlatitudes, is essential to resolve uncertainties in carbon balance of the world's terrestrial ecosystems. Long-term flux measurements are needed to quantify seasonal and annual variability of carbon and water exchanges from these ecosystems and to relate the variability to environmental and physiological factors. Such long-term measurements are of particular interest for different stand developmental stages. An understanding of environmental control factors is necessary to improve predictive capabilities of terrestrial carbon and water cycles. A long-term year-round measurement program has been initiated to observe energy, water vapour, and carbon dioxide fluxes in a chronosequence of white pine (Pinus Strobus) forests in southeastern Canada. White pine is an important species in the North American landscape because of its ability to adapt to dry environments. White pine efficiently grows on coarse and sandy soils, where other deciduous and conifer species cannot survive. Generally, it is the first woody species to flourish after disturbances such as fire and clearing. The climate at the study site is temperate, with a mean annual temperature of 8 degree C and a mean annual precipitation of about 800 mm. The growing season is one of the longest in Canada, with at least 150 frost-free days. Measurements at the site began in June 2002 and are continuing at present. Flux measurements at the 60 year old stand are being made using a close-path eddy covariance (EC) system, while fluxes at the three younger stands (30, 15 and 1 year old) are being measured over 10 to 20 day periods using a roving open-path EC system Soil respiration is being measured every 2-weeks across 50-m transects at all four sites using a mobile chamber system (LI-COR 6400). The mature stand was a sink of carbon with annual NEP value of 140 g C m-2 from June 2002 to May 2003. Gross ecosystem productivity (GEP) and ecosystem respiration (R) for 2002-03 were 1290 and 1150 g C m-2, respectively. A processed-based carbon simulation model was created by incorporating canopy physiology (photosynthesis - sunlit and shaded leaf, conductance), plant phenology (leaf out, senescence), and carbon balance (plant and soil respiration, ecosystem productivity) algorithms in the Canadian Land Surface Scheme. In this study, we compare observed and simulated energy, water vapour, and carbon dioxide fluxes of the mature stand with those of the younger stands. This comparison will help to resolve scaling issues for estimating water and carbon budgets from stands to regions.

URL: http://www.science.mcmaster.ca/geo/faculty/arain/research/index.htm

B51D-1002 0830h POSTER

Vegetated terrestrial ecosystems are large sources of Hg to the atmosphere

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Industrial processes, especially coal combustion and metal refining, have led to significant releases of Hg to the atmosphere during the last century. It has been hypothesized that a large percentage of this Hg has been deposited to terrestrial ecosystems via wet and dry deposition. Recent measurements of net Hg exchange between soils and the atmosphere indicate that terrestrial ecosystems are a source of Hg to the atmosphere, rather than the hypothesized sink, but very few measurements have been performed over vegetated terrestrial ecosystems. The objective of this study was to continuously measure net Hg exchange between a grassland ecosystem and the atmosphere during an entire year using the Ecologically Controlled Enclosed Lysimeter Laboratory (EcoCELLs) at Desert Research Institute. The EcoCELLs are unique open flow gas exchange systems that allow for the measurement of whole-ecosystem gas fluxes from large soil-plant monoliths under precisely controlled environmental conditions. Our results indicate that daily net ecosystem Hg exchange was positive (i.e., net Hg loss from the ecosystem to the atmosphere) during most of the year with the exception of the winter months when we observed net deposition of Hg to the ecosystem. Soil Hg fluxes only contributed between 10 % and 25 % of measured ecosystem Hg emissions. Ecosystem Hg fluxes showed pronounced diel patterns with higher daytime Hg emissions compared to nighttime Hg fluxes indicating that solar radiation, temperature, and evapotranspiration are important factors controlling Hg emissions. The cumulative annual Hg budget over one year indicated that the grassland ecosystem in our study was a relatively large Hg source to the atmosphere, ranging from 20 to 100 μ g Hg m^{-2}. Based on this study it appears that grassland ecosystems are sources of Hg to the atmosphere during most of the year, with vegetation greatly enhancing total emissions, possibly through transpiration, and that vegetated terrestrial ecosystems are large, yet still poorly quantified, sources of Hg to the atmosphere.

B51E MCC: Level 2 Friday 0830h

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

Presiding: **M Falk,** University of California, Berkeley**; C Song,** University of North Carolina at Chapel Hill

B51E-1003 0830h POSTER

Quantifying Representation and Using Representation Weights to Interpolate Flux Tower Measurements across the United States

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We are using a new multivariate statistical technique to quantitatively divide the lower 48 United States into a series of flux-relevant ecoregions. On the basis of these flux-relevant ecoregions, we will quantify the representativeness of the existing network of AmeriFlux towers, showing how well each ecoregion is represented by the current stations in the AmeriFlux network. Quantifying AmeriFlux representation will indicate the best locations where additional AmeriFlux towers should be placed. Using a "paint-by-number" approach, we are attempting to use the flux ecoregions as the statistical basis for extrapolating measurements made at the 52 actively-reporting AmeriFlux towers into a continuous 1-km grid across the United States seasonally. We will use the similarity of the suite of flux-relevant ecosystem characteristics to modify existing flux measurements and estimate fluxes within unmeasured flux ecoregions. Weights calculated for each environmental gradient will allow us to mix new "paint-by-number" colors, extending the process beyond the palette of existing flux measurements. The map of 2000 to 5000 flux ecoregions will produce a highly-resolved national map of estimated fluxes, and will be equivalent to creating thousands of new "virtual" flux towers across the nation. Once flux ecoregions and representation weights have been determined, it may be possible to use them to obtain an interpolated grid of the estimated flux at any point in time across the United States.

URL: http://research.esd.ornl.gov/~hnw/networks2

B51E-1004 0830h POSTER

Towards Constraining Regional Carbon Exchange In The Southern Great Plains With DOE ARM and COBRA Data And Tools

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Long term measurements of CO2 concentration and flux from tower sites may be effective for use in inversion estimates of regional land surface-atmosphere CO2 exchange. To explore the potential for application of tower data we have combined measurements from the 60m tower at the Atmospheric Radiation Measurement Program (ARM) Central Facility (36.61N, 97.49W) in the U.S. Southern Great Plains with a Stochastic Time-Inverted Lagrangian Transport (STILT) model [Lin et al., 2003] using a receptor oriented modeling (ROM) framework (Gerbig et al., 2003) developed for CO2 Budget and Regional Airborne Study (COBRA). We first investigate the uncertainties in the influence functions obtained from STILT: 1) STILT estimates of PBL heights show good correlation with those estimated from the radio sound profiles in May-June 2002 and 2003; 2) The measured mean concentrations on the 60 meter tower are independent of the flow directions patterns summarized from STILT particle trajectory statistics. Then we regress the observed CO2 concentration on the STILT/ROM simulated CO2 signals of different vegetation and emission sources in the growing season 2002 to obtain the scaling factors. The residuals are modeled as an autoregressive process to resolve the temporal correlation and calculate the uncertainties associated with the estimated coefficients. We find that: 1) STILT /ROM captures 60-80% of the variance in the observations; 2) Crop and shrub are the most important vegetation types that affect the regional carbon exchange; 3) Phenology and land use management cause significant seasonal variation in the scaling factors. Progress toward Bayesian inversion of the annual cycle of regional ecosystem-atmosphere CO2 exchange constrained by measurements from the 60m tower and aircraft flights, incorporating uncertainties in PBL heights, will be discussed.

B51E-1005 0830h POSTER

Characterizing Diurnal CO_2 Cycles in the Continental Boundary Layer Using Precise Concentration Measurements and a Simple Numerical Model

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In continental regions, atmospheric CO_2 profiles are strongly influenced by atmospheric dynamics as well as ecosystem and anthropogenic fluxes. Relating site level measurements or atmospheric profiles to regional CO_2 budgets may require methods to represent or evaluate these influences. At the Southern Great Plains ARM-CART, we are measuring precise CO_2 concentrations continuously at 2-60 m and weekly at 300 and 3300 m agl. CO_2 flux is measured in individual fields (4 m towers) and at 60 m. The precise CO_2 concentrations show strong continental influence in both diurnal and seasonal cycles. There is a vertical gradient in CO_2 concentration, with annual average CO_2 concentration at 2 m being 7 ppm higher than at 60 m, and flasks showing a 1-2 ppm difference between free troposphere and 60 or 300 m samples. To characterize the continental, diurnal cycle in CO_2, we have made a box model with three well mixed compartments for the surface layer,

boundary layer, and free troposphere. We have precise CO_2 measurements in all three compartments. Input data were limited to surface CO_2 flux, horizontal wind speed, and PBL height (estimated from discontinuity in potential temperature and vapor profiles measured by ARM radiosonde 4-8 times daily). The characteristic mixing times were tuned to the CO_2 data for limited time periods and model performance was evaluated against independent time periods. The model shows that the diurnal cycle in continental regions has three phases, distinguished by different driving mechanisms and trajectories of CO_2 concentrations. First, CO_2 buildup in the evening follows cessation of photosynthesis and increasing atmospheric stability. Second, the rapid decrease in atmospheric concentrations after sunrise is largely abiotic, driven by atmospheric mixing. Finally, the gradual draw-down of concentrations mid-day is determined by both net ecosystem uptake and the growing boundary layer. For longer time scales, the mass balance requires consideration of fair weather subsidence and consequent dilution of ABL air with air from the free troposphere. In summary, we are able to recreate the measured diurnal structure with a simple numerical model that is driven by regional CO_2 flux, PBL height, and horizontal wind speed. The model can be used to evaluate the sensitivity of the diurnal structure to these factors.

URL: http://esd.lbl.gov/ARMCarbon

B51E-1006 0830h POSTER

Interannual Variability in Regional-Scale Measurements of ecosystem-Atmosphere CO2 Exchange at the WLEF Tall Tower: A Testbed for Regional Scaling Methodology.

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We present the interannual variability of net ecosystem-atmosphere exchange (NEE) of CO2 observed from WLEF, a 447 meter tall tower in a mixed forest in northern Wisconsin. NEE data from this site are unique because the flux footprint is 10-100 times larger than the footprints of most Ameriflux towers. This large footprint integrates fluxes from a highly varied ecosystem, including upland forests, wetlands, managed areas, and disturbed areas. Unlike most North American flux towers, the NEE measured at WLEF is consistently positive, indicating a source of CO2 to the atmosphere. High-accuracy CO2 mixing ratio measurements at the site allow us to compare inverse and eddy-covariance methods of estimating NEE of CO2. Such comparisons will aid in our understanding of the spatial representativeness of eddy covariance measurements and the coherence of interannual variability in these measurements over large spatial scales. During the period 1997-2002, the WLEF flux footprint was observed to be an average source of 80 gC m-2 yr-1. The range of interannual variability over this six year period is about 125 gC m-2. This range is larger than the observed random and systematic errors at WLEF. Both disturbances and climate variations are observed to play roles in the variability of NEE, ecosystem respiration (RE) and photosynthesis. For example, a drought in 1998 and a caterpillar infestation in 2001 have significant impacts on NEE during the growing seasons of those years. Although soil temperature and photosynthetically active radiation (PAR) are excellent predictors of NEE on hourly to daily timescales, other climate variables such as precipitation and growing season length become important at monthly to yearly timescales. For the purposes of upscaling studies, it is important to understand why the WLEF region is a source of CO2. Although the WLEF flux tower footprint is a mix of forested wetlands and uplands, we cannot use a linear combination of NEE observations from our nearby wetland and upland small towers to obtain the NEE for WLEF. Both the wetland and upland sites are small sinks of CO2. This failure to upscale the smaller flux tower footprints to the large WLEF footprint is caused by values of RE that are consistently higher at WLEF than at the other towers. These high values of RE may be the result of several factors. Evidence exists that the water table in the region is dropping, possibly exposing organic matter formerly in wetlands to aerobic respiration. Management and disturbance also play significant roles in the WLEF footprint, but may not be important in the footprints of the smaller towers. The comparison of NEE variability at WLEF with NEE variability computed with inverse methods and of nearby sites will yield insight into the scale and the nature of the disturbance causing CO2 release at WLEF. This abstract focuses on an analysis of the causes of interannual variability and long-term net ecosystem release of CO2 at WLEF. Companion abstracts will discuss comparisons to the nearby wetland and upland towers, and experimental inverse approaches that are being attempted in the region.

B51E-1007 0830h POSTER

Correlation Between the Interannual Variability of the Vegetation Activity and the ENSO Cycle in the Tropics

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Monitoring the interannual variation of the vegetation productivity in the tropics is necessary to understand the global changes in carbon cycle and climate. Although tropical ecosystems must have been affected by ENSO cycle, the relation is not clarified yet. In this study, we analyzed the correlation between the normalized difference vegetation index (NDVI) originated from the Advanced Very High Resolution Radiometers (AVHRR) on NOAA satellites and the ENSO signal by means of Singular Spectrum Analysis (SSA). Assuming that ENSO cycle consists of the tropospheric biennial oscillation (TBO) mode (2-3 year) and the lower frequency variability (LFV) mode (3-7 year), we have extracted corresponding frequency components from time-series NDVI data from 1982 to 2000, and analyzed the relation to climate variability using the observed climate records. A certain portion of NDVI variation (around 20-30%) could be explained by the component with 2-7 years' periodicity. Seasonal analysis of NDVI and the Southern Oscillation Index (SOI) shows clear relationship between them in the most places over tropics (e.g. Amazon, Southeast Asia, and Central Africa). In addition, the strongest correlation with the SOI was found in DJF. It is suggested that the wet season (DJF) affects the vegetation growth. Correlation analyses of NDVI and climate variables (temperature, precipitation, incoming solar radiation, vapor pressure and cloud cover) were also carried out to identify the driving factor of ENSO-related NDVI variations. Precipitation and cloud cover variations shows good coincidence with NDVI variations. Since water is abundant over tropical rain forests, the cloud cover variation, which is related to incoming solar radiation, can explain the NDVI variation over tropics. Although the relationship between NDVI and incoming surface solar radiation was not detected well, one of the possibilities is due to the quality of radiation data. Our analysis indicates that tropical ecosystems are responding to climate changes due to ENSO. Further analysis will be focused on the quality of satellite data and comparison with terrestrial ecosystem modeling approaches.

B51E-1008 0830h POSTER

Linking Water Flux Parameterisation Schemes to Isotopic Measurements in Basin-scale to Climate Models

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Within the GEWEX (Global Energy and Water Cycle Experiment) Continental Scale Experiments (CSE) system, stable water isotope collection is co-coordinated by the International Atomic Energy Agency under its Global Network for Isotopes in Rivers (GNIR) and Global Network for Isotopes in Precipitation (GNIP). Simultaneous tracking of two isotopes in water (HDO and $H_2^{18}O$), makes it possible to trace the history of evaporative and condensation processes in the world's major river basins. Isotopic data from 1964 to 2000 show trends, possibly linked to land-use change impacts, at stations in the Andes, where as much as 88% of the Amazon's rainfall is shown (using isotopic measurements) to be derived from recycled moisture. We have compared twenty AMIP2 simulations for the CSEs with isotopic simulations from the Melbourne University GCM (MUGCM, Noone and Simmonds, 2002) which predicts the ^{18}O and ^{2}H concentrations in precipitation and atmospheric water vapor. Globally and in all the GEWEX regions, recent reanalyses products fail to conserve water because of soil moisture nudging and decreases in the soil moisture of more than 65% of the mean precipitation. VIC (Variable Infiltration Capacity) is found to conserve the surface water everywhere, providing reliable surface water simulations, when averaged over large areas and long periods of time (e.g. Nijssen *et al.*, 2001). Overall, we find that MUGCM generates surface water budget components for the GEWEX CSEs that match observations, including VIC, better than many AMIP2 models. For example, in the Murray Darling basin, an area poorly simulated by many AGCMs, the evaporation to precipitation ratio is 0.92 from observations, 0.86 in VIC and 0.98 when the AMIP2 AGCMS are averaged. For the runoff to precipitation ratio, these values are 0.08 from observations, 0.14 from VIC and 0.09 for the AMIP2 average. We find that MUGCM (generating 0.79 for E/P and 0.21 for R/P) behaves as well as the best performing land-surface schemes, the 'SiB-lings', but possibly for 'wrong' reasons, which are explained.

B51E-1009 0830h POSTER

Effect of Snow Formulation on Springtime Carbon, Heat and Moisture Fluxes in Northern Forests, Using the Simple Biosphere Model (SiB)

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The treatment of springtime fluxes of carbon, heat and moisture present a considerable problem to biophysical models at sites where canopy phenology shows a distinct annual cycle. At these sites spring is a time of change from dormant to active canopy, and many forest biomes shift from carbon source to sink during this period. Simulations made using the Simple Biosphere Model (SiB2.5) have produced unrealistically large carbon fluxes into the terrestrial biosphere over northern forest areas during the spring months. SiB2.5 commonly retains a thin layer of snow late into the spring, which acts to keep soil temperatures cold thus suppressing soil respiration. The result is net ecosystem exchange (NEE) values that are more representative of midsummer, and a premature conversion from carbon source to sink in model simulations. A reformulation of snow and soil processes in SiB version 3.0 remedies this problem; snowpack ablation is more reasonable in the springtime with the result that modeled fluxes are more self-consistent.

B51E-1010 0830h POSTER

Simulation of the Seasonal and Interannual Variability of Carbon and Water Cycles Within Three Mid-latitude Forests Using a Dynamic Global Vegetation Model

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Currently, a considerable challenge confronts the scientific community to acquire an improved understanding of the bi-directional exchange of carbon, water, and energy within the coupled biosphere-atmosphere system at the local scale using measurement strategies, with the goal of scaling these results to larger regions using modeling tools. The exchange of heat, moisture and trace gases that occur within the planetary boundary layer are dynamic and responsive to each other, occurring at a continuum of timescales ranging from seconds (e.g., plant physiology) to thousands of years (e.g., soil biogeochemistry). To address the need for more robust models of the biosphere that can capture processes which function across a continuum of timescales, a new class of dynamic biosphere models, termed Dynamic Global Vegetation Models (DGVMs), have been in continuous development and testing during the last decade. This group of models integrates biogeography, vegetation dynamics, soil biogeochemistry, and SVAT components into the same integrated framework, allowing for the continual update of vegetation and soil characteristics in response to plant competition, soil nutrients, and atmospheric forcing. The key objective of this study was to evaluate the ability of the Integrated BIosphere Simulator (or IBIS, a DGVM) to simulate seasonal and interannual surface-atmosphere exchanges of carbon and water within three mid-latitude AmeriFlux forest study sites (Walker Branch, Harvard Forest, and Niwot Ridge). We allowed for simulated vegetation structure to interact dynamically with changing atmospheric conditions in one set of simulations, while in another simulation, vegetation characteristics were fixed within the model. We used multiyear, half-hourly measurements of surface-atmosphere exchange of coupled carbon-water fluxes and observations of vegetation phenology (leaf area index), biomass, canopy height, soil carbon density, and surface runoff at these study sites to assess model realism. Specific questions we chose to address included: (1) Does the model satisfactorily simulate forest stand characteristics and associated seasonal and interannual carbon and water fluxes?; (2) How applicable are global scale model parameterizations at a local, field-site scale when simulations of forest stand characteristics and quantification of seasonal and interannual carbon and water fluxes are desired? Initial results indicated that under fixed vegetation conditions, the model satisfactorily captured the measured exchange of carbon and water between the surface and the atmosphere, suggesting that the SVAT component of the model was robust. Secondly, when simulated vegetation structure (leaf area, biomass, and canopy height) was allowed to interact dynamically with changing atmospheric conditions, the model reproduced vegetation height and total plant biomass within 20% for all three forests studied, while some improvement was noted in the simulated seasonality of carbon and water fluxes for broadleaved deciduous forests. We concluded that the use of a phenological modeling scheme that incorporates local climate characteristics is essential to capturing the seasonal and interannual variability in coupled carbon-water fluxes.

B51E-1011 0830h POSTER

Spatiotemporal Variability of Global and Diffuse PAR in the Amazon Region and its Significance for Tropical Forest Photosynthesis

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This study examines seasonal and inter-annual variation in surface fluxes of global and diffuse photosynthetically active radiation (PAR, 400-700 nm) in the tropical forest of the Amazon region. Spatial and temporal patterns of global and diffuse PAR are determined from reanalysis data from the National Center for Environmental Prediction (NCEP), and from the SeaWIFS Solar Surface Irradiance (SSI) data set. The PAR data and satellite-derived estimates of leaf area index (LAI) are applied to an existing sun-shade model of forest canopy photosynthesis. The seasonality of atmospheric scattering (quantified as the diffuse fraction of global PAR) as a determining factor for the relative influence of variation and trends in incident PAR on tropical forest photosynthesis is quantitatively evaluated. The results provide insight into the role of the surface PAR regime in the dynamics of ecosystem-atmosphere carbon exchange in the Amazon and other tropical forest regions.

B51E-1012 0830h POSTER

Bulk Canopy Conductance and NDVI Along a Precipitation Gradient During IHOP 2002 in the U.S. Southern Great Plains

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Bulk canopy conductance (Gc) of water was calculated from a rearranged form of the Penman-Monteith equation for nine surface flux stations across a precipitation gradient for different land-uses during the International H2O Project 2002 in the U.S. Southern Great Plains. Gc is compared to ground-based normalized difference vegetation index (NDVI) measurements from mid-May through late July 2002. The putative relationship of which - under optimal environmental conditions of high vapor pressure deficit (D), photosynthetic photon flux density (PPFD), and soil moisture (Theta) - may provide an upper bounds for Gc (Gcmax). Here we explore the relationship of Gcmax as a function of NDVI for optimal D, PPFD and Theta as well as the influence of suboptimal D, PPFD and Theta on this relationship to constrain Gcmax to Gc. The potential for separating Gc into its primary components of soil conductance (Gg) and stomatal conductance (Gs) is also examined using a log-linear model to calculate Gs, leaving the residual Gg. This could be useful in estimating Gc, which may allow subsequent separation of the relative contribution of Gg and Gs to Gc using the log-linear relationship of Gs to D in addition to constraints of PPFD and Theta on Gs. Such an approach could be especially powerful when combining satellite NDVI with remotely sensed soil moisture indices to generate these relationships.

URL: http://www.atd.ucar.edu/dir_off/projects/2002/IHOP.html

B51E-1013 0830h POSTER

Recent climate-induced variations in terrestrial carbon cycle over tropics: A model simulation

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Tropical forests accounts for about 20 percent of the world terrestrial carbon and one-third of global terrestrial NPP. Atmospheric inversion studies show that additional factors such as CO2 fertilization and climate changes, should work as a carbon sink despite of CO2 emission due to deforestation in tropical regions. However, responses of tropical ecosystems to environmental changes and current carbon sink mechanisms are still unknown. The goal of this study is (1) to characterize the climate influences on tropical carbon cycle such as GPP, NPP and NEP, and (2) to analyze recent interannual variations in terrestrial carbon cycle over tropics. We investigated the relationship between climate factors (temperature, precipitation, radiation, and VPD) and several carbon cycle components, and analyzed recent carbon cycle variations over tropics using Biome BGC with NCEP reanalysis climate data from 1982 to 1999. In tropical ecosystems, interannual variations in GPP are mainly explained by radiation variations, and temperature and precipitation variation are secondary important. NPP and NEP interannual variations are primarily determined by temperature variation, and radiation came as a secondary important factors. Precipitation, which was considered as an important climate factor that control interannual variations in carbon cycle in tropics, has little effects on interannual variation in tropical carbon cycle possibly because of abundant rainfall. Then, recent interannual variations in terrestrial carbon cycle over tropics were analyzed from 1982-1999. Tropics show gradual increases in GPP, NPP, and NEP at a rate of several percent per recent 18 years with large drop in 1998. Both climate change and CO2 fertilization have impact on recent enhancement of terrestrial carbon uptake. Of all climate factors, radiation-induced enhancement shows important role in enhancing CO2 uptake over Amazon. On the other hand, variations in precipitation and vapor pressure did not make any trend. We compared NCEP radiation data with other independent observations, and concluded that radiation-induced enhancement of terrestrial carbon uptake is certain.

B51E-1014 0830h POSTER

Remote sensing of net ecosystem productivity based on component spectrum and soil respiration observation in boreal forest, interior Alaska.

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We built a remote sensing method for leaf area index (LAI) and ground cover mosses / lichens in boreal forest by field component spectral observation and radiative transfer modeling based on the spectrum. The method was applied to evaluate annual net ecosystem productivity (NEP) distribution in boreal forest, interior Alaska by combining soil respiration observation synchronized to the spectral observation. Spectral reflectance and soil respiration were observed in two 30m X 30m plots in black spruce stands, central Alaska. Spectral characteristics of the forest floor and the needle leaves were used as input parameters of a radiative transfer model to evaluate nadir reflectances of spruce communities in relation to varying upper layer LAI, forest floor bryophyte types, and leaf spectral characteristics. Using the relationship, we obtained LAI and bryophyte area ratios for each pixel that corresponds to spruce forest on Landsat ETM+ imagery. The LAI-NPP relationship was estimated from Plonski's normal yield table data and specific leaf area, and NPP was calculated from LAI. Based on the observed annual soil respiration and NPP of upper layer and forest floor, annual NEP geographical distribution was estimated as a mean value in recent 30-100 years from remotely sensed LAI and forest floor bryophyte area ratios. The annually estimated NEP was 51 gC/m^2/year, which corresponds to the value (55 gC/m^2/year) of 150-year-old black spruce forest in the BOREAS study region, Canada.

B51E-1015 0830h POSTER

Mapping Forest Biomass Over Large Scales From Remote Sensing, Topographic and Climate Data

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To better understand dynamics in the global carbon cycle, improved methods are required to quantify the carbon stored in forest ecosystems over large areas. Remote sensing provides an obvious means for doing this, but robust and effective methods and data sources have proven elusive. We used a combination of remotely sensed data, topographic data, climate variables, and statistical methods to map above ground forest biomass for 89,000 km^2 of National Forest land in California. To do this, 1-km Nadir BRDF adjusted reflectances derived from the Moderate Resolution Imaging Spectoradiometer (MODIS) were used in combination with precipitation, temperature, and elevation data. Using these data, tree-based models were estimated to predict biomass within each 1-km cell. The models were validated using high resolution forest cover biomass maps produced by the United States Forest Service for the State of California. The results show that the tree-based models were able to predict forest biomass for land areas characterized by shrubs, hardwood forest, and conifer forest with a root mean square error of 44.4 tons/ha. Across all 89,000 km^2 (the whole study area) the models explain 73 percent of the variance in biomass. These results suggest that coarse resolution remotely sensed data, in combination with relevant topographic and climate data, can be used to map above ground biomass with reasonable accuracy over large areas and improve our ability to estimate stocks of carbon in existing vegetation.

B51E-1016 0830h POSTER

Remote Quantification of Vegetation Biophysical Characteristics: Algorithms, Calibration and Validation

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There is considerable interest in assessing biophysical characteristics of vegetation, such as vegetation fraction (VF), leaf area index (LAI), and the magnitude of carbon sources and sinks for agricultural lands, grasslands, and forests. In this paper, we discuss novel techniques to assess remotely VF, LAI and CO2 fluxes in crops. We suggest Visible Atmospherically Resistant Index (VARI) for estimating VF; VARI uses only visible (either green or red edge, blue, and red) spectral channels. The index showed linear relationship with VF in wheat, maize and soybean. To estimate LAI and green leaf biomass we used reflectances in two spectral channels either in the green around 550 nm, or in the red edge near 700 nm, and in the near infra-red (NIR) beyond 750 nm. The technique was tested in agricultural fields under maize and soybean canopies, and proved suitable for accurate estimation of LAI ranging from 0 to more than 6. To estimate CO2 fluxes we used a model developed for assessing leaf chlorophyll content. At canopy level the model relates total chlorophyll concentration in the canopy (per volume) with CO2 fluxes. Differences of reciprocal reflectances [(rGreen)-1-(rNIR)-1] and [(rRedEdge)-1-(rNIR)-1] accounted for more than 80 percent of the variability in mid-day canopy photosynthesis of maize and soybean. The technique was validated by an independent data set; root mean square error in predicting mid-day canopy photosynthesis was 0.17 mg/m2/s by [(rRedEdge)-1-(rNIR)-1] and 0.2 mg/m2/s by [(rGreen)-1-(rNIR)-1].

B51E-1017 0830h POSTER

Modeling seasonal vegetation variation and its validation against satellite-based observations

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Seasonal variation of vegetation, determined by plant phenology, impacts the seasonality of surface and atmospheric water cycles by controlling the leaf area available for transpiration. It also impacts the seasonality of land surface energy balance by controlling the intra-annual surface albedo changes. At the same time, leaf seasonal variations respond to both cumulative and concurrent hydro-meteorological conditions. In order to account for this vegetation feedback at the seasonal time scale, we incorporate a predictive plant phenology scheme into the land surface model CLM and evaluate its performance against satellite-based observations. The atmospheric forcing data from the NCEP/NCAR reanalysis is used to drive the land surface model, and the AVHRR Normalized Difference Vegetation Index (NDVI) is used for model validation. Existing problems and the need for further model development will be identified based on this work.

B51E-1018 0830h POSTER

Changes in Mongolia Vegetation Productivity (1982-1998) Derived From Satellite Observations

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Mongolia is dominated by rangelands that are utilized by humans for livestock grazing. Pastoral systems apply pressure to vegetation productivity that already may be stressed by water limitation. Northern Eurasia appears to be undergoing dramatic climate warming during the past several decades that also impacts the ecosystem dynamics in the region. Ninety percent of Mongolia is vulnerable to desertification, and recent overgrazing in recent decades is thought to be responsible for land degradation. A shift around 1990 in the sociopolitical system from collectivization to privatization has likely impacted Mongolian rangelands. In this study, we used a two-decade-long time series of the normalized difference vegetation index together with a carbon cycle model to assess recent changes in net primary production (NPP). Over the entire country, NPP has increased slightly during the 1982-1998 period. Comparisons with a map of soil degradation reveals both increases and decreases in areas with severe degradation, and areas not identified by the map exhibit decreases. We compared NPP from the first half of the record (1982-1990) with that of the second half (1991-1998). NPP generally decreased more in the 1990s and was substantially more variable than in the 1980s. Changes in precipitation and possibly climate warming coupled with land-use change likely drive much of this behavior.

B51E-1019 0830h POSTER

Recent geographic variations in terrestrial carbon cycle based on new production efficiency model

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The terrestrial carbon budget must be understood more accurately for the prediction of future changes in climate and carbon cycle. The goal of this study is to estimate spatial and temporal patterns of the carbon fluxes more accurately using the newly developed terrestrial biosphere model and satellite data. Our model consists of terrestrial carbon cycle and hydrology submodels. An advantage is a new approach in the LUE (Light Use Efficiency) concept, which calculates temperature and water stress factor in LUE model from a photosynthetic model and stomatal conductance formulation. In carbon cycle model, GPP is calculated from the LUE concept and satellite-based fPAR dataset. The soil carbon cycle model is based on CENTURY model with optimized water and temperature factor. Hydrological submodel is based on BIOME3, calculating ET is used by Penman-Monteith method. The model was run for 18 years (1982-1999) on a global scale, and we simulated the geographic distributions of the terrestrial carbon fluxes. We have checked simulated vegetation growth limiting factor with stress factor of MODIS NPP algorithm. Large differences were found in the northern mid and high latitude forests because soil moisture stress is not incorporated into MODIS NPP algorithm. Although responses of stress factors in MODIS NPP algorithm are mostly similar to our theoretically based one, our model works well in the soil moisture limited regions. Global total NPP was estimated at 61.7GtC/yr, and total NEP variations are strongly related with ENSO. Validation using measured values from the GPPDI database showed that our NPP estimation was within a reasonable range. The temporal patterns of the terrestrial carbon flux showed that NPP increased in the northern middle/high latitudes, central Africa, and India. In contrast, NPP decreased in the south Amazon region, the middle latitudes of the southern hemisphere, a part of North America, and Southeast Asia. Sensitivity analysis indicated that NPP variations were largely affected by fAPAR, solar radiation, temperature, and precipitation variations. Our new model was shown to be an appropriate tool to estimate the spatial and temporal patterns of the terrestrial carbon fluxes.

B51E-1020 0830h POSTER

Role of global oceanic forcing and local vegetation feedback in the 20th century Sahel drought: results from the coupled GENESIS-IBIS model

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Previous studies have indicated that both large-scale forcing from the ocean and land surface feedback may have contributed to the severe drought in the 20th century over the Sahel region. In this study we investigate the role of these two factors in the variability of the Sahel rainfall using a sophisticated global biosphere-atmosphere model GENESIS-IBIS. The observed global sea surface temperature in the 20th century are used as as the model driving forcing. Using this coupled global model, we experiment on treating vegetation as a static boundary condition and as a dynamic component of the earth climate system. Our results indicate that the global oceanic forcing can cause a severe drought in the simulated climate system with vegetation being a dynamic component. However, the 20th century Sahel drought may not have occurred if the vegetation were kept as static. Our study emphasizes the important role of dynamic vegetation in regulating the rainfall variability over the Sahel region, and confirms some previous findings from less sophisticated models.

B51F MCC: 3002 Friday 1020h

Human Interactions and the Carbon Cycle in North America *(joint with A, H, OS, GC, PA)*

Presiding: **L Dilling,** National Center for Atmospheric Research**; G Marland,** Oak Ridge National Laboratory

B51F-01 1020h

A review of the role of carbon cycle science in supporting carbon management policy

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Over the past few centuries, concentrations of carbon dioxide and other greenhouse gases have increased in the atmosphere, leading to potential changes in climate. Concern has risen such that societies are now contemplating actions designed to mitigate or prevent further increases. A variety of approaches has been suggested: direct reduction of emissions, deliberate manipulation of the natural carbon cycle to enhance sequestration, and capture and isolation of carbon from fossil fuel use. Policy development to date has laid out some of the principles to which carbon management should adhere, including quantification and verification, additionality and separation, permanence, and environmental acceptability. Much of this policy is still being debated, however, and many of the issues involve significant scientific and technological challenges. This presentation will summarize these carbon management principles, and briefly review examples of the scientific knowledge base available to support specific application of policy options. The issues of scaling of observations and mechanistic understanding of the carbon cycle in North America will be emphasized.