B42E-03 1555h

Do N2O-Emissions From N-Saturated Forest Soils Partly/ Fully Compensate For CO2-Sequestration?

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Nitrous oxide is a very powerful greenhouse gas in the atmosphere, estimated to have on a molecular basis a greenhouse gas potential 310 times more effective than CO2 (calculated on a C to N basis this value is 132.8). Continuous measurements of N2O emissions from N-saturated temperate forest soils in Germany over a more than 4 years period have shown, that such soils are significant sources for N2O. Though the N2O emissions were found to be highly variable in time (seasonal effects, freezing and thawing effects on N2O emissions) and space (small scale effects by e.g. stem flow, but also effects by forest type) we were able based on our huge database - to calculate reliable estimates for the source strength of spruce (1-2 kg N2O-N ha-1 yr-1) and beech forest ecosystems (3-5 kg N2O-N) for the years 1994-1997. During this time period the C-sequestration in woody biomass was in a range of 200-300 kg C ha-1 yr-1. Taking into account the N2O-emissions from both forest stands, this means that the spruce stand was a very week sink for greenhouse gases (here sum of N2O emission and CO2-sequestration), i.e. calculated for CO2 approx. 100 kg CO2-C ha-1 yr-1, whereas the beech stand was even a net source for greenhouse gases (i.e. calculated for CO2 >200 kg CO2-C ha-1 yr-1). Furthermore, we found that forest management, here clear cutting in January 2000 and re-establishment of a forest stand, had tremendous effects on the release of N2O from forest ecosystems. During the first two years after clear cutting more than 5 kg N2O-N ha-1 yr-1 were emitted from this site. At present we do not know, how long this effect will last and at which time the upcoming vegetation may reduce the increased N-availability in the soils. However, it is clear from our findings that in discussions about the potential of temperate forests as sinks for atmospheric CO2 the more potent greenhouse gas N2O cannot be neglected and that life time analysis of forest stand development is necessary in order to be able to decide whether N-saturated forest ecosystems are really net sinks for greenhouse gases at all.

URL: http://www.ifu.fhg.de

B42E-04 1610h

Impact of Canopy Nitrogen Deposition on Forest Carbon Storage: Initial Results from a manipulative Experiment at the Howland AmeriFlux Site

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We are conducting a large-scale ecosystem manipulation experiment to evaluate the hypothesis that anthropogenic nitrogen (N) deposition is enhancing forest ecosystem carbon sequestration. About 21 ha of spruce-hemlock forest in central Maine was fertilized at a rate of 18 kg N/ha/y in 2001 with additional applications planned in 2002-3. The N application is in liquid form to the canopy to more closely duplicate actual N deposition processes than previous studies that have applied fertilizer to the forest floor. The impact of this treatment on net ecosystem CO2 exchange (NEE) is being evaluated with the eddy covariance technique.

Model simulations suggest that with low-moderate N uptake efficiency (20-50 percent), canopy photosynthesis (GEE) and NEE will each increase in the experimental treatment by readily detectable amounts (7-17 percent and 12-33 percent) after the first year of N addition, with further increases possible in subsequent years. We are using 15N labeled fertilizer on subplots in the treatment area and biomass measurements to independently assess C sequestration changes and partitioning following N addition.

B42E-05 1625h

What do terrestrial biogeochemistry and chemical transport models tell us about the impact of nitrogen deposition on carbon and nitrogen cycling?

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Evaluation of the impact of increasing nitrogen deposition on terrestrial carbon uptake requires coupling of chemical transport models and terrestrial biogeochemistry models. Simulations with a series of models and coupling schemes combined with the measurements of nitrogen deposition produce a range of results which can be used to help guide further measurements and the establishment of a appropriate networks. To help narrow uncertainties of our understanding of regional N budgets, we produced maps of N deposition fluxes from site-network observations for the US and Western Europe. These two regions of the world which have undergone profound modification of bio-atmospheric N exchanges. The maps consist of statistically interpolated fields of aqueous nitrate and ammonium, nitric acid and nitrite, and particulate nitrate and ammonium, and the interpolated spatially continuous fields allow estimation of regionally integrated budget terms. Dry deposition fluxes were the most problematic because of low station density and uncertainties associated with exchange mechanisms at the land surface. We determined dry N deposition fluxes by multiplying interpolated surface air concentrations for each chemical species by model-calculated, spatially explicit deposition velocities. Deposition of the oxidized N species, by-products of fossil fuel combustion, dominate the US N deposition budget with 2.5 Tg of NO_x-N out of a total of 3.7-4.5 Tg of N deposited annually onto the conterminous US. Deposition of the reduced species, which are by-products of farming and animal husbandry, are slightly more than 50% of dominate the Western European N deposition budget with a total of 4.3-6.3 Tg of N deposited each year out of a total of 8.4-10.8 Tg N. Western Europe receives five times more N in precipitation than the conterminous US. For both regions, estimated N emissions exceed measured deposition in the US with an imbalance of 5.3-7.81. In Europe, estimated emissions better balanced measured deposition, with an imbalance of between 0.63 to 2.88. The difference in magnitude suggests that the export of N from the US is much greater, andor that the sites in the US may under-sample the deposition of urban emissions. The imbalance is also consistent with US export of N to Europe. We then used the maps of N deposition over the US coupled to Century simulations to evaluate the continental carbon and nitrogen budgets. These estimates of carbon storage were much smaller than previous estimates using a perturbation model.

B42E-06 1645h

Forest Canopy Uptake of Atmospheric Nitrogen at a Midwestern U.S. Mixed Hardwood Site: Implications for Carbon Storage

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This study investigates the potential of increased nitrogen (N) deposition to enhance carbon sequestration in temperate mid-latitude forests. We conducted detailed measurements of N deposition and cycling from an AmeriFlux tower in southern Indiana (MMSF). These measurements indicate an average atmosphere-surface N flux of approximately 6 mg-N m^{-2} d^{-1} during the 2000 growing season with approximately 40% coming from dry deposition of NH_3, HNO_3 and particle bound N. Total inorganic-N wet deposition fluxes during the growing season are comparable to those measured at NADP sites located in Indiana, Ohio and Kentucky, but the dominant form is NH_4^+ at MMSF and NO_3^- at the NADP sites. Canopy N uptake is often assumed to be negligible compared to root uptake; however, wet deposition and throughfall measurements indicate significant canopy uptake of N (particularly NH_4^+) with a net canopy exchange of 9-10 kg-N ha^{-1} estimated for the year. When multiplied by the carbon to nitrogen ratio in leaves and total aboveground biomass, potential enhancement of carbon storage at this site is equivalent to 200-2050 kg C ha^{-1} y^{-1}.

B51A MC: Hall D Friday 0830h

Water, Energy, and Carbon Cycles in Terrestrial Systems: Local-Scale Observations Through Fluxnet and Other Micrometeorological Tower Sites III *(joint with H)*

Presiding: **A W King,** Oak Ridge National Laboratory**; E Pattey,** Agriculture and Agri-Food Canada**; H Schmid,** Indiana State University

B51A-0164 0830h POSTER

Measuring the distribution of surface energy and water fluxes in a riparian mesquite savannah-type ecosystem.

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Eddy flux studies have traditionally focused on total ecosystem exchanges of energy and water by making measurements in the well-mixed surface layer. This approach does not give information about the partitioning of the total ecosystem fluxes between overstory and understory sources and sinks. In the more open canopy environment of a savannah, information about this partitioning of fluxes is often required in order to understand the relative importance and functioning of key ecosystem components. In this paper, we present some results from a series of multinational experiments carried out in a riparian mesquite (Prosopis velutina) forest. Three eddy covariance systems were deployed to measure energy, carbon and water fluxes. One was installed on a tower to measure whole ecosystem fluxes. The other two were installed at a height of 2 m, one in a relatively closed understory patch and the other in a more open understory patch, during periods before and after the onset of the summer rainy season. Our results highlight the fact that the trees had access to groundwater (10 m depth), and thus, they had a water use that was relatively insensitive to local precipitation. In contrast, the contribution of the understory to the total ecosystem fluxes was highly variable due to the presence or absence of precipitation.

B51A-0165 0830h POSTER

Energy, Water, and Carbon Dioxide Exchange of a Riparian Mesquite Stand

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Rapid population growth in semi-arid regions of the southwestern United States is increasing the demand for groundwater as a source of drinking water. However, vulnerable riparian corridors are often linked to these aquifers, as in the case of the San Pedro River in southeastern Arizona. In such basins, effective management of water resources requires accurate measurements of water fluxes, including the evapotranspiration from the vegetation in the riparian corridor. The riparian vegetation along the San Pedro River typically consists of a narrow strip of phreatophytes such as cottonwood (Populus fremontii) and willow (Salix goodingii), and a wider forest of mesquite (Prosopis velutina) which populates the lower river terrace. This paper describes a study in which energy, water, and carbon dioxide fluxes were measured over an open-canopy mesquite forest with an understory of sacaton bunchgrass (Sporobolus wrightii) and several annual species. Measurements were routinely made throughout the growing season in 2001 at a height of 14 m using eddy covariance techniques, and are used to provide an estimate of the seasonal water use of this riparian mesquite stand.

B51A-0166 0830h POSTER

Measurement and Partitioning of Net Carbon Exchange in a Coastal Salt Marsh

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A tower-based conditional sampling system was used from July 1997 through July 2000 to provide measurements of the carbon dioxide exchange of a salt marsh in the upper Nueces Delta near Corpus Christi, TX. Extensive channelization of the Nueces River has limited the water supply to the high marsh, resulting in high salinity, low productivity, and dry conditions. Studies were conducted to determine the effects of water availability on the CO_2 flux of the site. Measurements have shown freshwater inflow increases the net carbon exchange (NCE) of the marsh by increasing CO_2 assimilation and decreasing CO_2 efflux.

In addition, the effects of water availability on the partitioning of NCE are being studied by extrapolation of nighttime respiration measurements to determine total photosynthesis. While the average annual respiration rate does not appear to be affected by water availability, daily ecosystem respiration tends to increase during periods of drought. In addition, chamber measurements have been made to partition ecosystem respiration into its above- and belowground components. Results reveal that belowground respiration is approximately 20% of total ecosystem respiration, while aboveground respiration accounts for the remaining 80%. Thus, ecosystem respiration appears to be dominated by aboveground respiration, which could account for the stability in average annual ecosystem respiration.

B51A-0167 0830h POSTER

Soil and Atmospheric CO2 Exchanges in Great Basin Plant Communities

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Seasonal changes in net CO2 exchange for three plant communities typical of the cold desert Great Basin biome, and primary factors governing CO2 exchange are studied. The communities include Agropyron desertorum (crested wheatgrass), Artemisia tridentata (sagebrush) and Juniperus osteosperma (Utah Juniper). Net ecosystem exchange (NEE) was estimated for each site with open-path eddy covariance systems. Soil CO2 fluxes were independently estimated at local scales using both surface chambers and a new gradient method based upon continuous and passive monitoring of CO2 concentrations at various soil depths. Eddy covariance-determined NEE values were directed towards the soil surface in the early spring when water was available. As the ecosystems became drier, periods of downward flux became shorter, until fluxes were always upward in the crested wheatgrass and sage communities. The Juniper maintained some downward fluxes much longer into the summer, indicating net photosynthesis was sometimes greater than soil respiration. All sites responded rapidly to even small rain events, by exhibiting temporary downward NEE values.

Estimates of soil CO2 fluxes by surface chamber and gradient methods were in good agreement with each other, however, these were often inconsistent with the larger scale eddy covariance estimates, even in the absence of active vegetation. The causes of these apparent discrepancies are being investigated.

B51A-0168 0830h POSTER

Energy and CO_2 Fluxes From Contrasting Urban Environments (Marseille, France; Lodz, Poland; Baltimore, USA and Vancouver, Canada)

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Current understanding of heat and water fluxes in urban environments derives largely from short-term, summertime, observation programs at a restricted number of sites (largely, though not exclusively, residential areas in North America). Urban observations of CO_2 fluxes are even more limited. In the last year, we have initiated new measurement programs at four sites: central Marseille, France; central Lodz, Poland; and residential Baltimore, USA and Vancouver, Canada. These sites offer the possibility of examining spatial and temporal patterns in urban surface-atmosphere exchanges and the influence of anthropogenic activity over a range of meteorological and surface conditions. Site and surface characteristics are presented along with preliminary results which focus on a comparison among sites and within site variability.

B51A-0169 0830h POSTER

Processes governing yearly variations in carbon sequestration at a temperate deciduous forest

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Since 1995, processes governing the net ecosystem exchange (NEE) of carbon dioxide have been continuously investigated at the CFB Borden temperate mixed deciduous forest in Ontario, Canada. On a yearly basis, the rates of NEE for this forest range from 0.3 to 2.5 t C ha^{-1}. For the 1996 to 1999 period, the forest sequestered the most carbon and had the greatest seasonal carbon dioxide flux in 1997. This seasonal flux is defined as the average daily rate of NEE over the course of the growing period and is the single most important factor governing yearly NEE. Such factors as soil temperature, timing of soil thawing, and respiratory processes exert only minor influences on the yearly variability in NEE. In this presentation, we will provide evidence to support the hypothesis that maximum Rubisco capacity per unit foliage element is one key control on the NEE variability. Additionally, changes in diffuse photosynthetically active irradiance contribute to the variability observed in NEE. We will present results from both data analyses and outputs from a biospheric modeling system which was employed to investigate seasonal rates of NEE for the Borden forest.

B51A-0170 0830h POSTER

Seasonal and interannual variation in carbon dioxide, water vapor and energy fluxes in a northern temperate grassland

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We made eddy covariance measurements of carbon dioxide, water vapor and energy flux in a native Canadian grassland ecosystem during 1998-2001. Our study period included a year with near average precipitation (1999), a year with higher than average precipitation (1998), and a year with below average precipitation (2000). Our objective was to analyze the effects of interannual climate variation on ecosystem metabolism. Change in soil moisture was the most important ecological factor controlling carbon gain in this grassland ecosystem. Maximum gross photosynthesis and apparent quantum yield differed among years at the time of peak photosynthetic activity. The ecosystem accumulated a total of 112 g C per square meter from the time the eddy covariance measurements were initiated in June 1998 until the end of December 2000, with most of the C gained during 1998. Calculations of bulk parameters such as omega and the Priestley-Taylor coefficient indicated that evapotranspiration was strongly controlled by surface conductance in this grassland. A non-linear model that included functions for vapor pressure deficit, photon flux density, and available soil moisture explained a large proportion of the variation in the surface conductance data. In order to accurately model surface conductance, separate model coefficients need to be used for a wet year compared to average and drought years, which had very similar model coefficients. Our data indicated that carbon and water flux varies asymmetrically in response to interannual variation in precipitation, with increases in productivity and water-use in a wet year being much more pronounced than reductions in a drought year.

B51A-0171 0830h POSTER

Carbon and Energy Fluxes Over two Mid-Latitude Deciduous Forests: Interannual and Latitudinal Variations

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Hourly fluxes of energy, water vapor and CO2 are now available from two AmeriFlux sites in Indiana (MMSF, 39deg 10'N, 86deg 25' W, for the years 1998-2001, up to the end of the growth period) and Michigan (UMBS, 45deg 35' N, 84deg 42' W, for 1999-2001).

Both sites are in extensive hardwood forests of a similar age, but the composition and diversity of tree species is quite different between the two locations. The latitudinal separation of more than 6.5 degrees causes also marked differences in the biophysical forcings of the ecosystem exchange, such as variations in growing season legth, summertime length of day, and soil thermal regimes in winter. The Indiana site was affected by a severe drought over much of summer and fall of 1999, whereas the Michigan site was only marginally affected by it.

We present the seasonal carbon exchange dynamics and annual increments of net ecosystem exchange in the context of the energy and water availability and compare the results from four years of measurements in the light of these geographical and interannual variations in the ecosystem forcings.

B51A-0172 0830h POSTER

Long-Term Carbon Dioxide Exchange Measurements above Japanese Forests by FFPRI FluxNet

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AsiaFlux has started in September 2000. In the East Asia, the development of flux observation of heat, water vapor and carbon dioxide is expected for the various types of the terrestrial ecosystems especially characterized by the monsoon climate, complex terrain and human impacts. In relation to global change, the forest function of carbon dioxide uptake has attracted considerable attention, though the data insufficiency still stands in the way of positive discussion in the East Asia. Then we have to clarify the exchanging processes of energy and carbon dioxide between the forest and the atmosphere by intensive observations, and accumulate data for the establishment and the testing of biome models. In Forestry and Forest Products Research Institute (FFPRI), the flux observation of heat, water vapor and carbon dioxide was initiated at Kawagoe forest site in 1995. After the establishment of the fundamental instrumentation, the flux observation was extended to six forest sites, named FFPRI FluxNet, since 1999. Those are different in latitude and forest type, and widely distributed in Japan. In the presentation, approaches to determine the annual carbon dioxide uptake are introduced for individual sites; cool-temperate deciduous broadleaf forest (Sapporo), temperate beech forest (Appi), warm-temperate deciduous broadleaf forest (Kawagoe), temperate pine forest (Fujiyoshida), warm-temperate mixed forest on complex terrain (Yamashiro), and warm-temperate needle-leaf forest on complex terrain (Kahoku). We can report at present, the annual observed NEE in 2000 ranged from 286 to 566 $gCm^{-2}yr^{-1}$, which basically increases with the decrease of the latitude. This tendency may not be changed but the values will be modified, because the procedure for the data quality control is also now in progress.

URL: http://www.ffpri.affrc.go.jp/labs/flux/

B51A-0173 0830h POSTER

The Effects of Snowpack on Carbon Sequestration in a High Elevation Subalpine Forest

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Three years of continuous measurements of net ecosystem exchange of CO_2 over a high elevation coniferous forest at Niwot Ridge, Colorado have indicated the importance of wintertime snowpack to annual carbon uptake by the ecosystem. The snowpack provides the key trigger for initiation of plant photosynthesis by providing water via the beginning of the annual snowmelt. Carbon uptake occurs even though significant snow cover still exists (often in excess of 1 meter depth); however, isothermal conditions within the snow allows for delivery of liquid water to the soil. The timing of the transition from a phase of wintertime respiration to that of springtime net CO_2 uptake is very sensitive to soil and snowpack temperatures which vary on the order of a few tenths of degrees Celsius. These small temperatures changes are reflected directly in the soil moisture content of the upper layers of the soil. Once springtime net CO_2 uptake has begun, the snowpack also serves to suppress soil respiration by maintaining near-freezing temperatures in the soil. A further influence of the snowpack resides in its apparent control over the wintertime respiration rate from the soils. Data from two contrasting years (1999 and 2000) suggest that wintertime respiration rates were influenced by the amount of snowpack. A deeper late-winter snowpack led to larger respiration rates (by $\sim$ 25%), presumably by providing a larger degree of insulation over the soil and maintaining higher soil temperatures. Since $\sim$ 60% of the carbon taken up during the summer is lost via wintertime respiration, changes in the respiration rate under the snowpack can be quite significant to the total annual carbon budget for this ecosystem.

B51A-0174 0830h POSTER

Annual Variations in Ecosystem Respiration during an El Niño/La Niña Cycle in a Coniferous West Coast Forest

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Eddy-correlation CO_2 fluxes measured above a 51-year-old Douglas-fir stand were used to infer annual variations in ecosystem respiration (ER). The stand is located in the Coastal Western Hemlock biogeoclimatic zone that is characterized by yearly precipitation values around 1000 mm and a dry period in summer. The three years of measurements analyzed cover an El Niño/La Niña cycle (1998/1999) and an 'average' year (2000). To compute annual ER, first, a straight line was fitted to the relationship between soil temperature and the log-transformed net ecosystem exchange (NEE) at night. Annual totals were then computed by using the fitted relationships to calculate half-hourly ER throughout the year and summing these values.

The effect of applying standard quality control procedures suggested in the literature (stationarity, friction velocity thresholds, flux thresholds) on the estimated annual ER was investigated. Confidence limits of the annual ER were calculated from the confidence limits of the fitted relationships. While this uncertainty does not represent the actual measurement error, it serves as a gauge of the significance of removing values from the data set. Only the removal of cases of low friction velocity proved significant, i.e. the annual estimate converged when the threshold was increased.

The temperature response of ER was strongest during the comparatively wet and cold La Niña year (1999) and similar during the El Niño and the average years. Due to the generally lower temperatures in 1999, however, annual ER (1700 g C m^{-2} y^{-1}) was slightly less than in 1998 and 2000 (1870 and 1800 g C m^{-2} y^{-1}, respectively). NEE was -330, -390, and -400 g C m^{-2} y^{-1} in 1998, 1999, and 2000, respectively. Apparently, the slightly higher ER during the El Niño year (1998) led to a corresponding reduction of the carbon uptake. On the other hand, the reduction of ER in the La Niña year (1999) was accompanied by a reduction in gross ecosystem photosynthesis, leaving NEE virtually unchanged compared to 2000, the 'average' year.

B51A-0175 0830h POSTER

Measuring Nighttime CO2 Flux over Terrestrial Ecosystems using Eddy Covariance and Nocturnal Boundary Layer Methods

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This study presents typical net CO2 efflux observations measured at night over agricultural crops for several years near Ottawa, Ontario and over an old black spruce stand near Candle Lake, Saskatchewan during the intensive field campaigns of the BOReal Ecosystem Atmosphere Study (BOREAS). We used the eddy-covariance technique for windy nights and the NBL budget approach for calm nights. Criteria for screening data into windy or calm conditions were made using the friction velocity (u*) and the standard deviation of the vertical wind speed (sw). The threshold at which the 30-minute CO2 flux observations were independent of u* or sw and had limited scatter were determined to be in the range 0.075-0.1 m/s for u* and sw, and about 1.5 m/s for U for multiple years of corn and soybean data. sw 0.4 m/s was shown to be a good screening threshold over the black spruce canopy. Current methods for handling nocturnal CO2 data involve systematically replacing data during calm conditions where eddy covariance is deficient with those from windy conditions. This can lead to an overestimation of the nocturnal CO2 flux. We suggest a variation on this procedure, which, through the screening of entire nights, allows the retaining of an acceptable proportion of calm periods within predominantly windy nights. The NBL budget technique requires calm nights for measuring the respiration unless other budget terms are quantified. A good agreement was found between CO2 flux measured using the NBL approach when the NBL was well developed and the eddy covariance technique, when restricted to windy nights. The NBL profiles integrate a larger area than eddy covariance, which means that high-emission spots can be included with this kind of approach.

B51A-0176 0830h POSTER

Nocturnal CO_2 Fluxes and Understory Drainage Flows

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It has long been known that the eddy covariance (EC) method appears to underestimate fluxes of CO_2 relative to chamber measurements under conditions of light turbulence (low u*), primarily encountered at night. Although sometimes the storage term (accumulated CO_2 below the EC measuring point) accounts for most of the difference, at other times there is still a deficit. Traditionally this has been attributed to horizontal advection of the CO_2 away from the flux tower by drainage flows, but without any solid evidence in the form of understory measurements.

In this paper, we use data collected at the Harvard Forest (HF) to test the hypothesis that nocturnal CO_2 fluxes that are missed by EC plus storage can be accounted for by advection in the understory. During the summer and fall of 1999 and 2000, an array of sonic anemometers was deployed near the ground around the main flux tower at the HF, in order to determine: a) whether measurable drainage flows occur at this site; b) whether they coincide with periods of CO_2 flux deficit; and c) whether they can be shown to be divergent and able to play a role in the transport of CO_2. Our results, which suggest a more complicated picture, will be discussed.

B51A-0177 0830h POSTER

Using Daytime Eddy Covariance Measurements to Infer Nighttime Respiration and the Annual Carbon Balance of Three Boreal Forests

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Continuous measurements of annual carbon exchange in 2000 were made at three southern boreal forests using the eddy covariance (EC) technique as part of the Boreal Ecosystem and Monitoring Sites (BERMS) program. The BERMS program was initiated to ensure the long-term monitoring of climate and carbon exchange, and evolved from the Boreal Ecosystem Atmosphere Study (BOREAS). Here we compare estimates of annual ecosystem respiration (R) inferred from two respiration-air temperature algorithms - one based on nighttime high wind speed EC data and the other on daytime light-response characteristics. This approach is used to address the uncertainty in the annual carbon balance estimate due to problems associated with nighttime EC measurements. The annual carbon balance estimate for each forest ranged between 165 and 80 g C m^{-2} at southern old aspen (SOA), 12 and -16 g C m^{-2} at southern old black spruce (SOBS), and 47 and 17 g C m^{-2} at southern old jack pine (SOJP). These annual estimates indicate that old southern boreal forests range from a moderate sink (SOA) to a possible small source (SOBS). Annual R ranged between 1104 and 1367 g C m^{-2} at SOA, 1050 and 1062 g C m^{-2} at SOBS, and 738 and 751 g C m^{-2} at SOJP. This analysis indicates that R estimated from the daytime light-response function compared to the nighttime EC fluxes is significantly larger for SOA but is similar for SOBS and SOJP. Examination of the mean vertical wind speed, following Lee (1998), for each site suggests that R may be underestimated at SOA due to vertical advection and/or the development of thermal circulation such as cold air drainage. For example, Lee (1998) demonstrated that R at SOA could be underestimated by as much as 260 g C m^{-2} y^{-1}, which compares favourably with our estimated difference of 263 g C m^{-2} y^{-1}. Furthermore, an automated forest floor and tree bole chamber system operating at SOA confirms that carbon efflux is underestimated by nighttime EC measurements. It is also possible, however, that the observed differences in R are due to errors associated with the respiration parameter estimates.

The difference in the carbon balance between these forests is complex. Despite having the shortest growing season carbon sequestration is greatest at SOA due to a relatively large photosynthetic capacity. At the conifer sites, photosynthetic capacity is marginally larger at SOBS; however, annual carbon sequestration is smaller due to large R. From the daytime light-response analysis we demonstrate that the ecosystem light compensation point (λ) of these forests increases seasonally with air temperature. There is also some evidence to suggest that λ increases with forest age, suggesting that the potential for carbon sequestration may decrease for old growth forests.

B51A-0178 0830h POSTER

The Effect of Climate on the Residence Time of Soil Organic Carbon: A Comparative Analysis

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The micrometeorological technique of eddy covariance is a powerful tool for characterizing the carbon (C) budget of terrestrial ecosystems. However, few attempts have been made to link canopy-scale eddy exchange to soil C processes. Here, we develop a simple means of using the global eddy flux calculations to examine the role of climate on soil C decomposition rates. We then compare the results of the eddy covariance calculations to the temperature dependence of soil C residence times determined by three common methods: direct soil respiration measurements, radiocarbon uptake, and stable C isotope change following land conversion.

In the analysis, we used a single pool first-order decomposition model of soil C. We found that soil C turnover time decreases exponentially with increasing mean annual temperature ($r^2 = 0.91$ P < 0.0001) and precipitation ($r^2 = 0.64$ P < 0.0001). The relationship with latitude ($r^2 = 0.52$ P < 0.0001) is less clear than the relationship with temperature due to the complex relationship between mean annual temperature, mean annual precipitation, elevation, and latitude in different regions of the world.

In all four methods, the soil organic C turnover time decreases exponentially with increasing MAT. The similar slopes and intercepts of the eddy flux and chamber measurements, lends support for the robustness of micrometeorological techniques in measuring respiration. The similarities in the response of soil C turnover to temperature (both slope and intercept) for the eddy flux and ^{14}C-derived turnover times is especially encouraging in that bomb-^{14}C measurements do not rely on any of the assumptions that were used to calculate soil C turnover from eddy flux data. However, the ^{13}C isotope method yields a significantly different slope and intercept than the other three techniques, possibly due to differences in ecosystem types examined by this method and the fact that all sites examined using ^{13}C have been recently disturbed. The results of this work reinforce the recognized temperature dependence of soil C turnover, and suggest that eddy flux experiments are an important additional approach for studying the soil C budget.

B51A-0179 0830h POSTER

Sensitivity of Modeled Net Ecosystem Exchange to Uncertainty in Initial Ecosystem Carbon Stocks

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Net ecosystem exchange (NEE) is the difference between CO_2 uptake by canopy photosynthesis and CO_2 release in ecosystem respiration R_E. The latter is itself the sum of autotrophic (plant) respiration and heterotrophic (mostly decomposer) respiration. Respiration is generally conceptualized as a first-order rate process; respiratory CO_2 fluxes are proportional to the mass of live plant tissue or dead organic matter (or to some closely related variable such as sapwood volume). Accordingly, modeled R_E (and consequently NEE) is a function of ecosystem carbon stocks, the amount of carbon present at time t, and model results can therefore be dependent upon the carbon stock values C_0 used to initialize the model at the beginning of the simulation period. Model simulation of NEE at FLUXNET tower sites, whether for model testing or to calibrate models for extrapolation of tower results, thus requires site-specific estimates of carbon stocks in various ecosystem pools. Measurements of these stocks are often not available for particular sites, or it can be difficult or costly to make the measurements. Thus it is important to understand the sensitivity of modeled NEE to uncertainty in estimates of ecosystem carbon stocks. Using LoTEC (Local Terrestrial Ecosystem Carbon), a mechanistic model of ecosystem carbon dynamics, we present an analysis of model sensitivity to initial carbon stocks for a variety of FLUXNET/AmeriFlux sites. We describe the relative sensitivity of NEE to differences in initial plant, soil, and total ecosystem carbon. We use these sensitivities to infer the uncertainty in modeled NEE resulting from error or uncertainty in estimating initial carbon stocks. At the Walker Branch Watershed site, for example, modeled NEE is more sensitive to differences in soil organic carbon than differences in vegetation carbon, with sensitivity factors ($\Delta NEE/\Delta C_0$) of 0.097 and 0.021, respectively. An uncertainty of ± 490 $g\ C\ m^{-2}$ in soil organic carbon (approximately 10% of estimated soil C for the site) yields an uncertainty in modeled NEE of nearly ± 50 $g\ C\ m^{-2} y^{-1}$. These sensitivity factors can be used to estimate the precision with which carbon stocks need to be measured to resolve modeled NEE within specified tolerances.

B51A-0180 0830h POSTER

Quantifying Net Ecosystem Exchange from Multilevel Ecophysiological and Turbulent Transport Models: A Comparison Between Forward and Inverse Approaches

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In forested ecosystems, the complex vertical structure of the canopy plays a critical role in CO2 net ecosystem exchange (NEE). In order to quantify the contribution of different canopy layers on NEE, multiple approaches are developed and compared. The first approach is based on a one-dimensional ecophysiological-radiative transfer and turbulent transport model (hereafter referred to as forward model) that solve conservation equations for mean scalar mass and heat. It explicitly incorporates biophysical and ecophysiological mechanisms responsible for stomatal opening and carbon assimilation. The forward model is compared with three inverse methods, which rely on mean concentration profiles as input. To assess the performance of the models individually, they were compared to eddy covariance CO2 flux measurements conducted above the canopy at the Duke Forest AmeriFlux site for a wide range of atmospheric stability conditions. This study is the first to rigorously compare such a broad range of multi-level methods for the same stand and for a wide range of environmental conditions. The results show that the forward method outperformed all three inverse methods for unstable and neutral conditions. Poor agreement was obtained under stable conditions for all models. However, in an ensemble sense, all the methods performed comparably. Since the forward method requires detailed knowledge of the canopy ecophysiological and radiative transfer properties, which are difficult to obtain on a routine basis, a symbiotic use of these approaches is advantageous.

B51A-0181 0830h POSTER

Comparison of Measured and Modeled Land Surface Fluxes and States in a Successional Environment

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The accuracy of atmospheric and ecological global change predictions depends on the ability of models to capture the coupled, dynamic processes that control land surface exchanges of carbon, water, and energy. We report on a study that compares measured and modeled land surface fluxes of carbon, water and energy as well as state variables at a successional grassland of the Blandy Experimental Farm and at the Virginia Forest Research Facility in VA. Land use change from rye cultivation to harvest to secondary succession provides both abrupt and gradual changes in vegetation cover at Blandy, whereas the forest represents a system that has experienced gradual succession for approximately 40 years. A soil-vegetation-atmosphere-transfer (SVAT) model is used to simulate fluxes for comparison to standard eddy covariance and microclimate measurements. The model is based on the interactive soil biosphere atmosphere (ISBA) scheme modified to include more explicit coupling of carbon and water interactions. We evaluate the models ability to capture the coupled, dynamic processes controlling energy-water-carbon exchanges over a range of soil moisture, vapor pressure deficit, and vegetative conditions. A sensitivity analysis is performed to evaluate the microclimatic controls on specific exchange pathways for distinct ecosystem states (cultivated, bare, early succession, late succession). Time series tools such as spectral analysis are used to further elucidate the resonance of land surface processes with microclimatic forcings.

B51A-0182 0830h POSTER

Eddy Flux Measurements and Energy Balance Closure

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Closure of the surface energy balance is an objective constraint on daytime eddy flux measurements. Over tall canopies many sites report $(H + \lambda E)/(Rn - G) \approx 0.7$ whereas 100% closure is commonly achieved over short canopies. This observed failure of closure can be redressed to a large extent by proper consideration of averaging and coordinate rotation periods. At the majority of sites, coordinates are aligned by rotating post-facto into a frame that sets the mean vertical velocity $\overline{w} = 0$ over the averaging period T. The covariance of a scalar c then reduces to the eddy covariance: $\overline{wc} = \overline{w}\,\overline{c} + \overline{w'c'} = \overline{w'c'}$. At other sites, coordinates are aligned with the long term wind field or other criteria and then $\overline{w} \neq 0$ over the period T. At these sites the vertical mean advective component of the covariance, $\overline{w}\,\overline{c}$ is often ignored because it is noisy and may exceed $\overline{w'c'}$. Alternatively, the data series are detrended or filtered to reduce the unpredictable behaviour of $\overline{w}\,\overline{c}$. All these processes have the potential to remove vital low frequency contributions to the covariance. It can be shown formally that rotating coordinates so $\overline{w} = 0$ over the period T removes contributions to $\overline{wc}$ from motions with periods longer than T. At the same time contributions with period shorter than T are amplified. Setting $\overline{w}\,\overline{c} = 0$ in long term coordinates or detrending or filtering the time series have equivalent effects. If the low frequency covariance lost is significant, then the energy balance will no longer close and other fluxes will be similarly affected. The amount of flux lost depends upon the averaging period T and the low frequency content of the cospectrum. Through analysis of data sets from forest sites in Scotland, Australia and Brazil, we have shown that daytime cospectra over tall forests in convective boundary layers have significant content at periods much longer than typical averaging times. Complex terrain further increases low frequency content. Extending averaging and rotation times from 15 minutes to 4 hours increased energy balance closure from 70% to 100% at the Australian and Brazilian sites and also increased carbon fluxes by $\sim$ 20%. Over the short dense Scottish forest in mainly neutral conditions the low frequency content of $\overline{wc}$ was much smaller and the effect of increased averaging time was negligible.

B51A-0183 0830h POSTER

On the Measurement of Soil Heat Flux to Improve Estimates of Energy Balance Closure

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Measurements of soil heat flux (G) are required to test for energy balance closure at many fluxnet locations. Data quality is often evaluated by comparing total available energy, composed of net radiation (Rn) and G, to the sum of latent (LE) and sensible (H) heat fluxes as measured by eddy covariance. Unfortunately, G often receives minimal attention during an experiment because other flux terms (e.g., Rn and LE) are larger or require more complex instrumentation. However, G at certain time periods can account for 10 to 30 percent of Rn, especially beneath short vegetation. Thus, errors in G can confound energy closure tests and lead to erroneous conclusions about of eddy covariance performance. Research was conducted to evaluate difference methods for automating and improving measurements of G. Automated soil heat capacity sensors were combined with heat flux plates to measure conduction and changes in heat storage at different position in the soil profile. The heat capacity sensors were also used to measure soil water content and soil temperature. Data were collected beneath turfgrass, a tallgrass prairie and a juniperous forest. Field results and numerical models were used to study the best sensor configuration and data analysis algorithms. Practical guidelines for measuring and calculating soil heat flux will be presented.

URL: http://www.oznet.ksu.edu/envphys/

B51A-0184 0830h POSTER

Heat Flux above a Larch Forest in East Asia

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Larch is the dominant species of the boreal forests widely spreading over the northern part of East Asia. The presence of the forests has largely influenced the surface interaction with the overlying atmosphere. In order to estimate the role of the larch forests in the global carbon cycle and climatic system, flux monitoring is now in progress at a Japanese larch plantation in Northern Japan. The monitoring will continue until 2009 and tree thinning is scheduled in 2003. We report on measurements of heat fluxes above the forest for about one year. The study site (42.7N, 141.5E, elevation 115-140 m) is located on a flat piedmont with few undulations. The area of the larch forest is about 100 ha, and the canopy height is about 15 m. Heat and CO2 fluxes have been measured continuously at the height of 42 m using the eddy covariance technique since August 2000. For the flux measurements, a sonic anemometer-thermometer, open- and closed-path type CO2/H2O analyzers were used, and the outputs of were recorded by a datalogger at 10 Hz. 30-min mean fluxes were calculated; coordinate rotation, trend removal and density fluctuation (WPL) correction were applied. Net radiation (Rn), soil heat flux (G), air temperature, humidity, precipitation, etc. were also monitored. Sensible heat flux (H) was highest in the beginning of March when the leaves of larch trees began to expand, and gradually decreased with the expansion of the leaves, while latent heat flux (lE) increased during this period and reached the maximum in July and August. Consequentially Bowen ratios of daily-integrated fluxes decreased from over five to less than one. Daily Bowen ratios began to increase in the middle of October when yellow coloring of the leaves began, and the values were over one in the winter season. Daily heat fluxes measured over the forest (H + lE) were almost always less than available energy (Rn G); the ratios were 0.6 to 0.9.

URL: http://www-cger.nies.go.jp/moni/moni-e

B51A-0185 0830h POSTER

Variations in the Surface Energy Balance Over Sagebrush: Implications for Energy Balance Closure

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Micrometeorological studies using the eddy covariance method often underestimate some component(s) of the surface energy balance, and hence fail to "close" the energy budget. Reasons cited for this include: a footprint "mismatch" between the turbulent flux measurements, net radiometers and soil heat flux plates, due to spatial variability within the measurement area. To investigate this we compared the net radiation, latent and sensible heat flux, soil heat flux, and soil moisture at a stationary site relative to a mobile site positioned for one week at 10 locations. Over an extensive sagebrush site in northeastern Colorado during June-August 2001, we found that the energy balanced closed to within 10% (half-hour basis) both at our mobile and stationary sites, located at distances of 16 and 32 m along N, S, E and W transects (one and two times the peak footprint of the mobile site). All of the energy balance components at the mobile site were within 5-10% (half-hour basis) of those measured at the stationary site regardless of the mobile site's position. We conclude that at this site, point measurements are representative of this ecosystem, and that our missing energy was not a result of spatial heterogeneity.

B51A-0186 0830h POSTER

A Comparison of Several Sonic Anemometers

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Most climate change researchers rely on the eddy covariance method for estimates of carbon dioxide fluxes and energy partitioning information. These estimates, in turn, require high precision measurements of wind speeds and temperatures. These measurements are most often obtained from sonic anemometers. Many researchers use instruments from one of three manufacturers

We present here, results of an intercomparison of anemometers from two of these manufacturers. The core of our comparison is focused on sensible heat flux (H) and friction velocity (U*). In addition, we will examine mean values of rotated horizontal wind speed (U), sonic temperature (T), and the standard deviation of the vertical wind. These parameters have the greatest impact on eddy covariance transport calculations, and their relative quality is of great importance in the selection of instrumentation.

B51A-0187 0830h POSTER

Evapotranspiration Methods Compared on a Sierra Nevada Forest Ecosystem

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Evapotranspiration, as a major component in terrestrial water balance and net primary productivity models, is often difficult to measure with instruments and predict with models. This study compared five potential evapotranspiration models applied to a ponderosa pine forest ecosystem at an Ameriflux site in Northern California. We measured fluxes of water vapor and sensible heat by the eddy covariance method at the Blodgett Forest Research Station in the Sierra Nevada Mountains over two climatically different growing seasons (1997 was drier than the climatic mean, and 1998 was cooler and wetter than the climatic mean influenced by El Nino). We estimated actual evapotranspiration rates based on the latent heat flux measurements. We also logged environmental variables that are known to influence evapotranspiration rates, such as net radiation, wind speed, air temperature, and relative humidity. The evapotranspiration models ranged from simple temperature- and solar radiation-driven equations to physically-based combination approaches and included reference surface and surface cover-dependent algorithms. Vorosmarty et al. (1998) compared a similar set of models, but on a global scale. For each evapotranspiration model, results were compared against mean daily latent heat from half-hourly measurements recorded on a tower above the forest canopy at the Blodgett Forest Research Station in California. All models calculate potential evapotranspiration and thus overpredicted values from the summer seasons of 1997 and 1998 because soil moisture was not at field capacity. Development of a soil moisture function to connect potential with actual evapotranspiration resulted in significant improvement on three of the five models. In our study, Shuttleworth-Wallace, Penman-Monteith, and McNaughton-Black all yielded similar results. A modified Priestley-Taylor method performed well given its relative simplicity. As was found in Vorosmarty et al. (1998), the Penman method performed poorly.

B51A-0188 0830h POSTER

The Influence of Vegetation Type on the Surface Water and Energy Balance in Semiarid Ecosystems

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The transition from semiarid grassland to shrubland occurs over a distance of 1 km in the Sevilleta Wildlife Refuge in New Mexico. The spatial variability of precipitation, incident shortwave radiation, and other factors is minimal across the ecotone because the transition zone spans such a short distance. Therefore, we assume that the type of vegetation is the primary

factor controlling the spatial variations of water and energy cycling at this location. We examine fluxes in the grassland, shrubland, and the intermediate mixed environment to isolate the influence of vegetation type on the exchange of water and energy between the land surface and the atmosphere.

Three micrometeorology sites span this shrub-grass ecotone. The Bowen Ratio-Energy Balance method is used at two of the sites and an eddy covariance system is used at the third site. We have intercompared the Bowen ratio and eddy covariance methods at each site. The differences introduced by using these two different methods are negligible compared to the observed spatial and temporal variability.

We present data from two summer monsoon seasons. The response to precipitation events is dramatic and similar at all three sites across the vegetation gradient. The latent heat flux at midday changes from nearly 0 when the soil is dry to greater than 250 W m-2 for several days following rainfall. These temporal fluctuations are much greater than the spatial differences associated with vegetation cover observed under either wet or dry conditions. However, the drydown following rainfall, and the attendant variations in water and energy fluxes, is different across the ecotone. In the shrubland, soil moisture and evapotranspiration decrease more quickly than in the grassland.

B51A-0189 0830h POSTER

Partitioning of Evapotranspiration Measurements Over a Heterogeneous Forest Cover

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Evapotranspiration fluxes were measured above a forest consisting of burned and unburned surface covers to determine evapotranspiration rates from each surface cover. Each 30-minute-resolution flux measurement by the eddy correlation sensors represented a composite of fluxes from the two surface covers. The relative contribution of each surface cover to the composite flux measurement was determined by the composition of the surface cover within the source area of the measurement. The source area occurred upwind of the flux sensors and, therefore, changed with time-varying wind direction. A time-varying source area, along with surface heterogeneity, meant that the relative contribution of each surface cover to the composite flux varied with time.

To better establish the contribution of each surface cover type, a method was developed to partition daily values of measured evapotranspiration flux into burned and unburned components. The partitioning for a given daily flux was estimated based on the distribution of wind direction during that day, along with the spatial distribution of surface cover in the vicinity of the flux measurement. Partitioning of daily fluxes also accounted for diurnal variations in evapotranspiration through weighting of wind direction data by values (of photosynthetically-active radiation) that are representative of intra-day temporal variability in evapotranspiration.

Data collected during a two-year period (1998-99) at a recently burned (June 1998) forest in central Florida were partitioned into burned and unburned components using this method. Results indicated that evapotranspiration in the burned areas initially was suppressed as a consequence of vegetation destruction. Specifically, for the 10-month period after the fire (July 1998-April 1999), the mean evapotranspiration from unburned areas was about 17 percent higher than from burned areas. However, during the subsequent 8-month period (May 1999-December 1999), the mean evapotranspiration from burned areas was about 31 percent higher than from unburned areas, possibly related to phenological changes associated with maturation and/or seasonality of plants that emerged after the fire.

B51A-0190 0830h POSTER

Non-Controlled Emission of Light Hydrocarbons (C_2-C_6) to the Atmosphere From Arico's Landfill, Tenerife, Canary Islands, Spain

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Light hydrocarbons play a significant role in the atmospheric chemistry because some of them act as precursors of photochemical smog production. Landfill gas is constituted by a large number of hydrocarbons and their oxidation products, as well as others organic compounds. In order to control the migration and emission of landfill gas through the landfill surface and adjacent rock, gas control systems are in use. However, significant amount of non-controlled emission of major and trace landfill gas components could be emitted to the atmosphere in a diffuse form. In this study, we estimate the "non-controlled" emission rate of light hydrocarbons (L.H.) from Arico's landfill situated in the island of Tenerife. Arico's landfill has an extension of 0.35 Km^2, and 1,170 tons of urban solid waste, which contains an average of 48% of organic matter, is daily deposited. A surface gas efflux survey is being carried out in the Arico's landfill. Diffuse CO_2 efflux measurements are being performed by means of a portable NDIR sensor according with the accumulation chamber method. CO_2 efflux reach values of 1,014 $gm^{-2}d^{-1}$. At each sampling site, landfill gas samples are also collected at 40 cm depth using a metallic probe and analyzed within 24 hours for CO_2, C_2H_6, C_3H_8, C_4H_{10}, C_5H_{12} and C_6H_{14} concentrations by means of a VARIAN microGC QUAD. The highest observed C_2H_6, C_3H_8, C_4H_{10}, C_5H_{12} and C_6H_{14} concentrations to date were 946.4, 285.1, 29.9, 32.5 and 14.2 ppmv, respectively. On the contrary, CO_2 content reach levels up to 36%. Light hydrocarbons fluxes were estimated by multiplying CO_2 efflux times (L.H.)i/CO_2 ratios at each sampling site, respectively. Observed maximum L.H. degassing rates are 2,523, 760, 1713, 259 and 241 $mgm^{-2}d^{-1}$, respectively. Spatial distribution analysis of this date suggest clearly a non-uniform pattern of degassing at landfills. These findings suggest important environmental and engineering implications related with "controlled" and "non-controlled" emission of landfill gases.

B51A-0191 0830h POSTER

Measuring Carbon Balance in the Amazon Basin: Woody Vegetation Dynamics in an Old-Growth Tropical Rainforest

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To address the question of Amazonian carbon balance we are using ground-based biometry measurements combined with whole-system CO2 fluxes via eddy covariance at an old-growth tropical forest (Tapajos National Forest, Santarem, Para, Brazil). Here, we focus on the biometry measurements (see Saleska, et al. abstract for discussion of eddy covariance), which include woody growth increment, tree recruitment and mortality, litterfall, and stocks of biomass as coarse woody debris and forest floor litter. Biometry measurements provide an independent check on carbon balance via eddy covariance, and also elucidate the ecological and climatic controls on the interannual carbon balance. Here, we characterize woody vegetation structure, present results of the first 2 years of above ground woody increment growth, and discuss the initial year of litter collection. Initial results indicate an approximate carbon balance between high growth rates and high damage and mortality rates.

B51A-0192 0830h POSTER

Carbon Balance in the Amazon Basin: Factors Influencing the Accuracy of Eddy Covariance Measurements

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To assess the role of Amazonia as a source or a sink for atmospheric CO2, we are using ground-based biometry measurements together with whole-system CO2 fluxes (via eddy covariance) to explore the ecological and climatic controls on the carbon balance at an old-growth Amazon forest (Tapajos National Forest, Santarem, Para, Brazil). Here, we focus on the initial 6 months of eddy covariance results from a new system that measures eddy covariance at two levels (47 m and 58 m) and measures canopy CO2 storage in two ways: by cycling through tower-mounted sample inlets at 8 levels (over 16 minutes), and by making a single integrated measurement of all 8 levels simultaneously. The integrated canopy storage measurement gives a storage flux estimate with much lower noise than the more conventional method of interpolating through separate measurements staggered in time, allowing for improved estimates of net ecosystem exchange (eddy flux + storage flux). This provides a cleaner way to identify nighttime periods when turbulent mixing was weak. We show that such periods of weak mixing clearly cause underestimates in flux, but that a continuous low-noise storage flux measurement can make adjustments for the effects of such periods more robust. After adjusting for periods of weak mixing, this tropical forest site appears to be in approximate carbon balance during this 6-month period – in agreement with the biometry observations over the first two years that woody biomass increment is in approximate balance with tree mortality.

B51A-0193 0830h POSTER

The partitioning between latent and sensible heat flux at FLUXNET sites

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The partitioning between ecosystem latent (LE) and sensible (H) heat fluxes is critical for understanding the hydrological cycle, predicting boundary layer development, weather and climate. The FLUXNET network provides a unique opportunity to investigate the partitioning of latent and sensible heat fluxes at the surface over a broad range of vegetation types and climates. This paper focuses on two aspects of surface flux partitioning at more than 20 sites worldwide. The first focus is on the relative partitioning between latent and sensible heat fluxes, or the Bowen ratio, during the warm season. We investigate the Bowen ratio across vegetation types and climates, and suggest controlling climatological and ecological factors. The surface resistance, which is related to the ability of the vegetation to supply available water and is one factor controlling the Bowen ratio, was generally lower at the agricultural and deciduous forest sites compared to coniferous forests. The ratio of the atmospheric humidity deficit to the net radiation (proportional to the climatological resistance), a second important factor controlling the Bowen ratio, was generally lower at sites near large bodies of water or over tundra vegetation, and was greater at more continental sites. The second focus of the study is on the diurnal trends of latent and sensible heat fluxes. We quantify the diurnal pattern of turbulent energy fluxes using the diurnal centroid, which is an indicator of whether the fluxes peak in the morning or afternoon. The diurnal centroid provides useful signatures of important physiological and climatological factors that control surface fluxes. These factors include stomatal closure, advection, atmospheric stability and vegetation height. Sites with tall vegetation and/or high wind speeds in continental regions with limited affects of advection, a stable and dry atmosphere and weak stomatal sensitivity to atmospheric humidity deficits or water potential tend to have late diurnal peaks in latent heat flux relative to sensible heat flux. Alternatively, sites with short vegetation, prominent advection from maritime sources, a weakly stable and moist atmosphere and a strong stomatal sensitivity to humidity deficit or water potential will have earlier peaks in latent heat flux relative to sensible heat flux.

B51A-0194 0830h POSTER

Roles of volcanic eruptions, aerosols and clouds in global carbon cycle

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The cataclysmic eruption of Mt. Pinatubo in 1991 released about 20 megatons of sulfur dioxide into the stratosphere. It brought markedly changes to the surface radiation environment over the globe in the next two years with significant enhancement in diffuse radiation (+50% in 1992) but only a small reduction in global solar radiation (<5%). Immediately after the eruption, the rate of atmospheric carbon dioxide rise dropped. Results from d13C measurements and atmospheric inverse modeling studies indicate that this rate

drop was due to enhanced carbon uptake by the terrestrial biosphere during the two years following the volcanic eruption. The surface cooling scenario suggests that the enhanced terrestrial carbon uptake is caused by reduced soil and plant respiration in response to the volcanic cooling. This explanation is questionable for two reasons. First, estimates put the volcanic cooling on the order of 0.5K. This is small and well within the natural range of temperature variability. Second, carbon cycle model estimates of terrestrial responses based on the surface cooling scenario led to direct contradictions with atmospheric inverse models in terms of regional patterns of carbon uptake after the Pinatubo eruption and with atmospheric oxygen measurements. Here we suggest that the increased diffuse radiation is the primary factor for the enhancement in terrestrial biosphere carbon uptake and therefore the dip in the rate of atmospheric carbon dioxide rise during the two-year period following the Pinatubo eruption in 1991. Using tower flux measurements from a variety of vegetation sites, we will demonstrate that plant canopies have higher quantum use efficiencies for diffuse radiation than for direct beam radiation. The superiority of diffuse radiation over direct beam radiation for canopy photosynthesis increases with radiation level. We will show that under a turbid atmospheric environment where part of the reduction in direct beam radiation is converted into diffuse radiation, terrestrial ecosystem productivity can be enhanced. In addition, we will discuss how clouds can increase terrestrial carbon sequestration.

B51A-0195 0830h POSTER

Pressure Pumping Effects on Fluxes and Release of Trace Gases From Soils

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New evidence, obtained at the Glacier Lakes Ecosystem Experiments Site in the Rocky Mountains of southern Wyoming, is presented that supports the hypothesis that turbulent pressure fluctuations can affect the flux of CO_2 and other trace gases from soils and snowpacks. First, half-hourly measurements of CO_2 mole fraction taken between December 2000 and March 2001 at the soil/snowpack interface under a 1.1 m snowpack show significant variations with a dominant period of about 8 days and an amplitude of about 100 ppmV. These variations are strongly correlated with fluctuations in both wind speed and pressure. Second, simultaneous CO_2 fluxes, taken as part of the AmeriFlux network, increase with increasing wind speed and decreasing CO_2 mole fraction at the soil/snow interface. These eddy covariance fluxes are greater than purely diffusional fluxes through the snowpack. Third, an analytical model of CO_2 fluxes throught the snowpack is used to distinguish between the effects of low frequency barometric pumping and the relatively higher frequency turbulent pressure pumping and stationary pressure waves forced by topography. Comparison of the observations and the modeling results suggest that turbulent pressure pumping can significantly enhance purely diffusional CO_2 fluxes on a half-hourly basis and that the intensity of the turbulent pressure pumping is modulated by the low frequwncy synoptic scale.

B51A-0196 0830h POSTER

SEASONALITY OF ECOSYSTEM RESPIRATION AND GROSS PRIMARY PRODUCTION AS DERIVED FROM FLUXNET MEASUREMENTS

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Differences in the seasonal pattern of assimilatory and respiratory processes are responsible for divergences in seasonal net carbon exchange among ecosystems. Using FLUXNET data (http://www-eosdis.ornl.gov/FLUXNET) we have analyzed seasonal patterns of gross primary productivity (GPP), and ecosystem respiration (RE) of boreal and temperate, deciduous and coniferous forests, mediterranean evergreen systems, rainforest, temperate grasslands, and C3 and C4 crops. Based on generalized seasonal patterns classifications of ecosystems into vegetation functional types can be evaluated for use in global productivity and climate change models. The results of this study contribute to our understanding of respiratory costs of assimilated carbon in various ecosystems.

Seasonal variability of GPP and RE increased in the order tropical, Mediterranean, temperate coniferous, temperate deciduous, boreal forests. Together with boreal forests, managed grasslands and crops show the largest seasonal variability. In temperate coniferous forests, seasonal patterns of GPP and RE are in phase, in temperate deciduous and boreal coniferous forests RE was delayed compared to GPP, resulting in the greatest imbalance between respiratory and assimilatory fluxes early in the growing season.

Gross primary productivity adjusted for the length of the growing season decreased across functional types in the order C4 crops, and temperate and boreal deciduous forests (7.5-8.3 g C m-2 d-1), temperate conifers, C3 grassland and crops (5.7-6.9 g C m-2 d-1), rainforest and boreal conifers (4.6-4.9 g C m-2 d-1). Annual GPP and NEP decreased across climate zones in the order tropical, temperate, boreal. However, the decrease in NEP was greater than the decrease in GPP, indicating a larger contribution of respiratory (especially heterotrophic) processes in boreal systems.

B51A-0197 0830h POSTER

Preliminary Results of the Carbon, Heat, and Moisture Turbulent Measurements over a Pasture in Eastern Amazon.

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This study presents preliminary results from a 10 years old pasture site located in the Amazon Region as a part of the Large-Scale Biosphere-Atmosphere Experiment in Amazonia (LBA). In this location a 20 m tower was installed to monitor micrometeorological and trace gases measurements. An eddy covariance system was installed at 8.75 m, composed by a 3D sonic anemometer (SATI/3K), and a CO2/H2O gas analyzer (licor 6262). Wind (CATI/2 - 12.25, 5.73, and 3.12 m), temperature and humidity (Vaysala Humitter, CS500, at 6.09, 4.14, 2.20 m), and CO2 (licor 6262 at 11.81, 5.29, 2.71, and 0.5 m) profiles have also been measured. At the top of the tower (17.76 m) upward and downward solar (Kipp and Zonen, CM11/14) and terrestrial (CG2) radiation is also collected. Soil temperatures (Campbell 108 at 0.10, 0.24, 0.50,1.50, and 2.0 m), soil heat flux (Campbell HFT3 at 0.30 m), and soil moisture (Campbell CS615 at 0.30 m) have also been installed. A Linux based PC machine records all data, and the are processed and stored at nearly real time. The site is powered by a solar panel that can provide continuously 500 W/m2. The data have been collected since September 2000.

In eastern Amazon the climate can be divided in dry (about July to December) and wet (about December to June) seasons. We present the seasonal changes of the turbulent fluxes (momentum, heat, moisture, and CO2). Also, we are going to present the seasonal differences for other related parameters such as albedo, bowen ratio, and the canopy photosynthesis as a function of the photosynthetically active radiation (PAR) curves for both seasons. The turbulent kinetic energy budget and the surface energy are evaluated to determine the accuracy of flux measurements.

B51B MC: Hall D Friday 0830h

Carbon and Nitrogen Interactions in Terrestrial Ecosystems

Presiding: **H Sievering,** Colorado University at Denver**; D Hollinger,** USDA Forest Service

B51B-0198 0830h POSTER

The Relationship Between DOC Partition Coefficient and Mineral Soil C:N Ratio

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Since our recent publication showing that soil C:N predicts DOC flux at local and global scales, an effort has been made to understand mechanisms controlling the relationship between the two variables. We have approached this at multiple scales, using soil batch experiments, soil column experiments, and long-term field manipulations. We present here the results from our batch adsorption experiment. Mineral soils from tropical (wet and moist) and temperate (coniferous and hardwood) forests were used to assess DOC adsorption by the initial mass isotherm approach. We found that the DOC partition co-efficient (m) which represents a soil's tendency to adsorb DOC is strongly and inversely related to mineral soil C:N ratio ($R2 = 0.99$ $n = 10$ $p < 0.001$). The intercept of the mass isotherm, or the desorption term, was positively related to mineral soil C:N ratio ($R2 = 0.80$ $n = 10$ $p < 0.01$), but we found that desorption of DOC was more closely correlated with equilibrium DOC concentration ($R2 = 0.97$ $n = 10$ $p < 0.001$) than with mineral soil C:N. The mass isotherm approach is also useful in calculating the reactive soil pool (RSP), the fraction of the soil pool of organic carbon that may be lost to leaching. The RSP was not significantly related to mineral soil C:N, but tropical soils tended to have a larger RSP than temperate soils. Although some of the tropical soils came from areas where the natural forest had been cleared, used for plantations and then abandoned, the relationship between DOC adsorption and mineral soil C:N was not compromised. Watershed soil C:N ratio is an excellent predictor of DOC export because soil C:N is related to physiochemical adsorption processes in mineral soils and biotic production of DOC in organic soil horizons. It appears that soil C:N is a relatively robust predictor of soil solution DOC concentration and surface water DOC export for ecosystems undergoing environmental stress.

B51B-0199 0830h POSTER

Effects of Forest Management on CO2 and N2O Emissions From Beech Forest Ecosystems in Germany

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The effects of forest management practice (partial clear cutting) on greenhouse gas emissions (CO2, N2O) and total gaseous N-losses by denitrification from soils of beech forest ecosystems was studied since April 1999 at two beech stands stocking on slopes exposed to the NE located at the Schwäbische Alb in SW Germany. One beech stand remained untreated and served as a control, while the other beech stand had been partially clear cutted in April 1999 (by removing approx. 50 % of the trees) for studies on the effect of forest management on greenhouse gas fluxes. The following parameters were determined during 6 field campaigns (April 1999-October 2000) and in laboratory studies: in situ N2O- and CO2 emission rates from soils were followed at c. 2-hourly resolution by the static chamber technique using fully automated measuring systems; denitrification losses of N2O and N2 were quantified in the lab using intact soil cores taken at the measuring sites during the measuring campaigns. For quantification of these N-losses a newly developed method was used.

The following results were obtained: Effect of forest management (comparison: partial clear cutted site vs. control site): for the first year of observation (1999) in situ N2O and CO2 emissions as well as total gaseous