B42D-04 1415h

Controls over Carbon Fluxes in a High Elevation Subalpine Forest

Russell K Monson[1,2] (303-492-6319; Russell.Monson@colorado.edu); Andrew A Turnipseed[1] (aturnip@colorado.edu); Jed P Sparks[1] (Jed.Sparks@colorado.edu); Peter C Harley[3] (harley@ucar.edu); Laura E Scott-Denton[1] (Laura.Scott@colorado.edu); Kimberly Sparks[1] (Jed.Sparks@colorado.edu); Travis E Huxman[1] (Travis.Huxman@colorado.edu)

[1]Department of EPO Biology, University of Colorado, Boulder, CO 80309, United States

[2]Cooperative Institute for Research in Environmental Science, University of Colorado, Boulder, CO 80309, United States

[3]Atmospheric Chemistry Division, National Center for Atmospheric Research, Boulder, CO 80301, United States

We studied net ecosystem CO_2 exchange (NEE) dynamics in a high-elevation, subalpine forest in Colorado, USA, over a two-year period. Fundamental features of forest structure and turbulence are reported, including an estimated leaf area index of 4.2 m^2 m^{-2}, canopy gap fraction of 17%, canopy height of 11 m, displacement height of 7.6 m, and roughness length of 1.79 m. Assuming similarity to sensible heat flux, summertime turbulent fluxes for CO_2 and H_2O occur at frequencies less than 1 Hz. Annual carbon sequestration for the forest was 81 and 58 g C m^{-2} for each of the two years. Despite its evergreen nature, the forest did not exhibit net CO_2 uptake during the winter, even during periods of favorable weather. The largest fraction of annual carbon sequestration occurred in the early growing-season; during the first 30 days of both years. Reductions in the rate of carbon sequestration after the first 30 days were due to higher ecosystem respiration rates when mid-summer moisture was adequate (as in the first year of the study) or lower midday photosynthesis rates when mid-summer moisture was not adequate (as in the second year of the study). The lower annual rate of carbon sequestration during the second year of the study was due to lower rates of CO_2 uptake during both the first 30 days of the growing season and the mid-summer months. The reduction in CO_2 uptake during the first 30 days of the second year was due to an earlier-than-normal spring warmup, which caused snow melt during a period when air temperatures were lower and atmospheric vapor pressure deficits were higher. The reduction in CO_2 uptake during the mid-summer of the second year was due to an extended drought, which was accompanied by reduced latent heat exchange and increased sensible heat exchange. Day-to-day variation in the daily-integrated NEE during the summers of both years was high, and was correlated with frequent convective storm clouds and concomitant variation in the photosynthetic photon flux density (PPFD). The results of this study are in contrast to those of other studies that have reported increased annual NEE during years with earlier-than-normal spring warming. In the current study, the lower annual NEE during 2000, the year with the earlier spring warm-up, was due to (1) coupling of the highest seasonal rates of carbon sequestration to the spring climate, rather than the summer climate as in other forest ecosystems that have been studied, and (2) delivery of snow melt to the soil when the spring climate was cooler and the atmosphere drier. Furthermore, the strong influence of mid-summer precipitation on CO_2 uptake rates make it clear that water supplied by the spring snow melt is a seasonally-limited resource, and summer rains are critical for sustaining high rates of annual carbon sequestration.

B42D-05 1430h

Measuring the Effect of Selective Logging on Tropical Forest-Atmosphere Exchange

Scott D Miller[1] (sdmiller@uci.edu); Mike Goulden[1] (mgoulden@uci.edu); Mary Menton[1] (mary@tap.com.br); Marcy Litvak[1] (mlitvak@uci.edu); Michela Figuera[1] (michela@tap.com.br); Cleilim Sousa[1] (albert_bio@hotmail.com); Humberto da Rocha[2] (humbertof@model.iag.usp.br); Helber Freitas[2] (helbercf@model.iag.usp.br); Leandro Della V.O.Pinto[2] (leandro@model.iag.usp.br)

[1]University of California at Irvine, 220 Rowland Hall Dept. of Earth System Science, Irvine, CA 92697-3100, United States

[2]University of Sao Paulo, Rua do Matão, 1226 Departamento de Ciências Atmosfricas, São Paulo, SP 05508-900, Brazil

We are using long-term eddy covariance to directly measure the effects of selective logging on the energy and trace gas exchange of a tropical forest, as a component of the Large Scale Biosphere-Atmosphere Experiment in Amazonia (LBA). We began measurements in June 2000 above a primary evergreen stand in the Tapajos National Forest (km 83), Para, Brazil. Logging occurred in September 2001. Approximately 2.5 trees per hectare were cut in the direction east of the tower (the climatological wind direction, or tower footprint). A larger fraction of the canopy was removed during logging due in part to vines that join adjacent crowns. Collaborators at Harvard University are making comparable measurements at a nearby site (km 67) that will not be logged, providing an experimental control for the logged site. The first year of eddy flux measurements suggest considerable net CO2 sequestration, consistent with other eddy flux measurements in Amazonia. However, a closer examination indicates that the turbulent flux at 65 m may substantially underestimate nighttime respiration during low winds and stable stratification. Measurements at both sites are expected to continue for at least three years. We will use our measurements from the three years following the cut to determine how much carbon is lost, when and if the forest resumes carbon accumulation, and how selective logging affects energy and hydrological balance.

B42D-06 1445h

Effects of spatial heterogeneity on sampling errors in CO2 flux measurements over uneven-aged forests

Peter E Levy[1] (44 131 445 8556; plevy@ceh.ac.uk)

Dennis Baldocchi[2] (510 642 2874; baldocchi@nature.berkeley.edu)

[1]Centre for Ecology Hydrology, Bush Estate, Penicuik EH26 0QB, United Kingdom

[2]University of California, Berkeley, Ecosystem Science Division, Department of Environmental Science, Policy and Management, 151 Hilgard Hall, Berkeley, CA 94720, United States

Net ecosystem productivity data from the FluxNet network of eddy covariance flux tower sites are currently being used to infer carbon sequestration by terrestrial vegetation. Long-term measurements from these sites have often found positive values of NEP. When scaled up using simple methods, these measurements imply higher rates of regional-scale carbon sequestration than are calculated by inverse modelling of the atmospheric CO2 concentration. This has raised the question as to whether there are biases inherent in the eddy covariance technique itself, or in the scaling procedures, which complicate the interpretation of the data. It has been suggested that the spatial heterogeneity within uneven-aged forests would cause large systematic sampling errors in tower-based flux measurements. This phenomenon can be quantified in terms of the sensor location bias, the degree to which a flux measured at a given location differs from the aggregated landscape-scale flux. Here, we applied (1) a modelling approach to quantify the sensor location bias in eddy covariance measurements of CO2 fluxes over virtual forests; and (2) an analysis of IKONOS satellite images, to identify the degree of spatial heterogeneity around actual FluxNet tower sites, and the associated sampling error.

B42E MC: 122 Thursday 1520h

Carbon and Nitrogen Interactions in Forest Ecosystems

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

B42E-01 1520h

The Coupled Nature of C and N Cycles in Forest Ecosystems: Evidence, Implications and Uncertainties

Scott V. Ollinger[1] (603-862-1792; scott.ollinger@unh.edu)

John D. Aber[1] (603-862-1792; john.aber@unh.edu)

Herman Sievering[2] (303-556-4277; hsieveri@carbon.cudenver.edu)

[1]University of New Hampshire, Complex Systems Research Center, Morse Hall, Durham, NH 03824, United States

[2]University of Colorado at Denver, Department of Geography, Geology, and Environmental Sciences, Denver, CO 80217, United States

Cycles of carbon and nitrogen in forest ecosystems are mutually and interactively linked through a shared set of biological processes. A large number of field studies across diverse biomes have documented strong and generalizable relationships between foliar nitrogen concentrations and rates of net photosynthesis. This trend reflects the fact that the majority of N in plant canopies is found in the proteins responsible for CO_2 capture (e.g. rubisco). In soils, the accumulation and availability of nitrogen is, in turn, affected by the quality and N content of litter inputs from vegetation. Taken together, these patterns reflect the broadly-coupled nature of terrestrial C and N cycles and suggest that human alteration of any aspect of one cycle can have important implications for the other. Nevertheless, the exact nature of C-N interactions in natural ecosystems can depend on a variety of factors including historical disturbance patterns, the effects of carbon quality on decomposition and N turnover, and the resulting differences in plant-soil feedbacks among species and functional groups. All of these factors greatly complicate efforts to characterize present-day patterns of C and N fluxes across real forested landscapes. Further, human-induced increases in atmospheric CO_2 and N deposition hold the potential for either tightening the linkages between C and N cycles, or causing them to become uncoupled.

This presentation will build on basic concepts to address several broad questions regarding C-N interactions in forests, both as they occur naturally and as they may be affected by elevated CO_2 or N deposition: 1) What evidence is available from the field to demonstrate the coupled nature of C-N cycles in native forest ecosystems? 2) How are C-N interactions in forests influenced by the growth and allocation strategies of different species and/or functional groups? 3) To what degree are current C and N cycles reflected in the chemistry of forest foliage, and 4) Is there evidence to support the notion that that elevated CO_2 or N deposition have altered normal C-N interactions? These questions will be addressed by examining results from several experimental studies with specific focus on a recent field study conducted in the White Mountain region of New Hampshire. That study was aimed at examining relationships between canopy properties, net primary production and soil N dynamics in temperate forest ecosystems and assessing the degree to which these variables can be estimated through remote sensing of canopy chemistry. Results demonstrate relationships between a number of canopy properties and fluxes of C and N, but also highlight interesting differences in natural plant-soil feedbacks among deciduous versus evergreen species.

B42E-02 1540h

Interactions of Carbon Gain and Nitrogen Addition in a Temperate Forest

Fakhri A. Bazzaz[1] (617-495-0916; fbazzaz@oeb.harvard.edu)

Sebastian Catovsky (+44 (0)20 7594 2483; s.catovsky@ic.ac.uk)

[1]Harvard University Dept. of Organismic Evolutionary Biology, Biological Laboratories 16 Divinity Ave. , Cambridge, MA 02138, United States

In plants, carbon and nitrogen are intimately related. The plant gains carbon using nitrogen because it is a major constituent of both the light reaction (chlorophyll) and dark reaction (Rubisco and PEP carboxylase). The plant also gains more nitrogen by using carbon to grow roots that can forage for nitrogen, especially the less mobile (NH4+). Rising CO2 and increased nitrogen deposition are important elements of global change, both of which may affect ecosystem structure and function. They may cause a particularly large shift in species composition in systems where contrasting groups of species co-occur, e.g. evergreen coniferous and deciduous broad-leaved tree species. We studied the impact of nitrogen deposition in a mixed forest in central Massachusetts (Harvard Forest). We found that the early-successional broad-leaved species, yellow birch (Betula alleghaniensis) and red maple (Acer rubrum), both showed large increases in biomass, while the late successional species sugar maple (Acer saccharum) and all the coniferous species, hemlock (Tsuga canadensis), red spruce (Picea rubens) and white pine (Pinus strobus), only showed slight increases. As a result, when these species wre grown together, there was a decrease in species diversity. There was a significant correlation between species growth rate and the growth enhancement following nitrogen addition. We used SORTIE, a spatially explicit forest model to speculate about the future of this community. In both hemlock and red oak stands, nitrogen deposition led to shift in forest composition towards further dominance of young forests by yellow birch. We conclude that seedling physiological and demographic responses to increased nitrogen availability will scale up to exaggerate successional dynamics in mixed temperate forests in the future

B

B42E-03 1555h

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

Klaus Butterbach-Bahl[1] (+49-8821-183136; butterbach@ifu.fhg.de)

Hans Papen[1] (+49-8821-183130; papen@ifu.fhg.de)

[1]Fraunhofer Institute for Atmospheric Environmental Research, Kreuzeckbahnstr. 19, Garmisch-Partenk. D-82467, Germany

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

David Y Hollinger[1] (davidh@hypatia.unh.edu); John Aber[2] (john.aber@unh.edu); Bryan Dail[3] (bryan.dail@maine.edu); Eric Davidson[4] (edavidson@whrc.org); Ivan Fernandez[3] (ivan.fernandez@maine.edu); Stewart Goltz[3] (goltz@maine.edu); Monique LeClerc[5] (mleclerc@venus.griffin.peachnet.edu); Herman Sievering[6] (hsieveri@carbon.cudenver.edu)

[1]USDA Forest Service, NE Research Station 271 Mast Rd., Durham, NH 03824

[2]Complex Systems Research Center, University of New Hampshire, Durham, NH 03824

[3]Department of Plant, Soil, and Environmental Sciences, University of Maine, Orono, ME 04469

[4]Woods Hole Research Center, Box 296, Woods Hole, MA 02543

[5]Dept. of Crop and Soil Sciences, University of Georgia, Athens, GA 30602-7411

[6]Institute of Arctic and Alpine Research, University of Colorado Campus Box 450 1560 30th St., Boulder, CO 80309-0450

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?

Elisabeth A. Holland[1,2] (303-497-1433; eholland@ucar.edu)

[1]Atmospheric Chemistry Division, National Center for Atmospheric Research, PO Box 3000, Boulder, CO 80305

[2]Max Planck Insitute for Biogeochemsitry, Postafch 10 01 64, Jena 07701, Germany

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

Sara C. Pryor[1] (812-855-5155; spryor@indiana.edu); Rebecca J. Barthelmie[1,2]; Margaret Carreiro[3]; Melissa L. Davis[1]; Anne E. Hartley[4] (614-733-0784; hartley.74@osu.edu); Bjarne Jensen[5]; Andrew Oliphant[1]; J. C. Randolph[6]; Justin T. Schoof[1]

[1]Indiana University, Atmospheric Sciences Program, Department of Geography, Bloomington, IN 47405, United States

[2]Risoe National Laboratory, Department of Wind Energy, Roskilde DK-4000, Denmark

[3]University of Louisville, Department of Biology, Louisville, KY 40292, United States

[4]The Ohio State University, Department of Evolution, Ecology and Organismal Biology, Columbus, OH 43210, United States

[5]ATMI, National Environmental Research Institute, Roskilde DK-4000, Denmark

[6]Indiana University, School of Public and Environmental Affairs, Bloomington, IN 47405, United States

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.

Russell L Scott[1] (520-670-6380x113; russell@tucson.ars.ag.gov); Christopher Watts[2] (watts@cideson.mx); Jaime Garatuza[3] (garatuza@yaqui.itson.mx); Eric Edwards[4] (rick@tucson.ars.ag.gov); David Williams[5] (dgw@email.arizona.edu); David Goodrich[1] (goodrich@tucson.ars.ag.gov)

[1]United States Department of Agriculture (USDA) Agricultural Research Service, 2000 E. Allen Rd, Tucson, AZ 85719, United States

[2]Instituto del Medio Ambiente y Desarrollo Sustentable (IMADES), Reyes y Aguacalientes, Hermosillo, Son 83190, Mexico

[3]Instituto Tecnolgica de Sonora, Obregon, Sonora, Obregon, Son, Mexico

[4]Department of Hydrology and Water Resources, University of Arizona, Tucson, AZ 85721, United States

[5]Department of Renewable Natural Resources, University of Arizona, Tucson, AZ 85721, United States

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.