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Recent microbiological surveys of terrestrial and oceanic subsurface biosphere have revealed that sizable microbial populations are present in the global subsurface environments. However, little is known about the community structure, the genetic diversity and the distribution pattern of the subsurface bacteria and archaea since these surveys are mainly dependent on microscopic observations and conventional cultivation techniques. Culture-independent, molecular phylogenetic techniques are now applied to explore microbial communities in various subsurface environments such as underground mines, subterrestrial rocks, continental and ocean oil reservoirs, subseafloor pelagic sediments and methane hydrates, and subvent microbial ecosystems. It becomes apparent that unique archaeal components are commonly present in these subsurface microbial habitats whereas archaea are always less abundant than bacteria. Most frequently recovered genetic signatures are of hyperthermophiles Thermococcus and extreme halophiles Haloarcula members. Unexpected ubiquity of them even in non-extreme, subsurface environments may represent the great mass potential of probably dormant extremophilic archaea in the global subsurface biosphere. Archaeal populations in deep-sea hydrothermal vents and the subvent environments might serve as sources of the dormant extremophiles, the silent majority of archaea. It seems likely therefore that the global and local ocean hydrothermal activities persistently have a great impact on the formation of subsurface microbial communities and the distribution of subsurface microorganisms. In the KR01-09 cruise which was named ?geomicrobiological investigation of subseafloor biosphere associated with deep-sea hydrothermal activity in the Okinawa Trough?, active populations of hyperthermophilic archaea Thermococcus were detected from non-hydrothermal subseafloor sediments. Their viability was likely correlated with the distance and the duration from the deep-sea hydrothermal vent activities. It will be discussed how the extremophilic archaea are propagated in the global subsurface biosphere.

B32C-06 1445h

Biological Origin of Micro-laminated Calcium Carbonate Deposits on Antarctic Rock Surfaces

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We have observed and sampled patchy encrustations of calcium carbonate on rock surfaces in East and West Antarctica. Individual disk-like deposits are up to 1 cm across and a few mm thick, but in places coalesce to form more extensive, colloform coatings. We have observed these deposits on substrates of granite, sandstone, and schist. Their distribution appears similar to that of Antarctic lichens and endolithic algae, extending up to ca. 1000m elevation, but has no consistent relationship to snow drifts, solar radiation, or prevailing winds. The morphology and position of the deposits are distinct from sub-glacial carbonate precipitates. In Marie Byrd Land, the encrustations occur on the surfaces exposed by deglaciation within the past 5000 yrs, and the sample from East Antarctica contains live C-14 (M. Mabin, pers. comm.), suggesting a possible biological origin

Electron microprobe and SEM examination of cross-sectioned specimens reveals micron-scale layering of predominantly calcium carbonate, but with a number of bright laminae in SEM images, believed to be calcium fluoride. Sections closely resemble desert varnish in micro-morphology, though not in mineralogy. Isotopic analysis of an organic carbon extract (as opposed to C from the CaCO3 itself) gave a delta C-13 PDB value of -23.3 per mil, similar to values expected in carbon of biological origin. However, we have no proof yet that the carbon analyzed was produced by organisms within the encrustation, rather than being entrapped during an inorganic precipitation process. To investigate the possible biological origin of this material, we attempted to sequence the 16S segment of rRNA in the organic extract, but have not yet completed successful PCR replication. We are continuing attempts to isolate and analyze the pertinent genetic material.

The micro-morphology, strongly negative delta C-13 and presence of live C-14 suggest a biological process for precipitation of these calcium carbonate deposits. We hope to be able to test this in future by comparing extracted genetic material with that from known psychrophilic bacteria. If this Antarctic material proves to be biological in origin, it may yield insights into the adaptation of organisms to conditions of extreme cold, aridity and UV exposure on Earth, or elsewhere in the Solar System.

B32C-07 1500h

Biologically-Induced Mineralization by the Endolithic Lichen *Verrucaria rubrocincta* Breuss in the Sonoran Desert

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Verrucaria rubrocincta is an endolithic lichen that inhabits exposed caliche in southwestern Arizona. It has developed a survival strategy against the high photon fluxes, aridity, and temperature extremes of the Sonoran Desert. The lichen occurs within the surface of caliche plates. *Verrucaria rubrocincta* -inhabited caliche can be distinguished from uninhabited substrate by the abundance of reddish-black fruiting bodies protruding through the rock surface. The lichen invades the rock from the edges. It grows beneath a 50 to 150 μmsurface precipitate of fine-grained calcite (micrite). Below the micrite is the upper medulla, ca. 120 μmthick, characterized by an abundance of algal cells. Fungal hyphae penetrate up to 1 cm into the caliche. The micrite layer is dominated by calcite with minor quantities of weddellite ($CaC_2O_4.H_2O$), and detrital quartz. Ca-oxalates are absent in the unaltered caliche. The micrite is enriched in ^{13}C ($\delta^{13}C$ = 8.1) relative to the underlying caliche ($\delta^{13}C$ = 0.0). It is therefore ca. 5 per mil enriched in ^{13}C relative to calcite in isotopic equilibrium with atmospheric CO_2, indicating that the light carbon is fractionated into organic material hence leaving heavy CO_2 to form carbonate. The heavy ^{13}C enrichment suggests that the micrite layer is not strictly a biological precipitate but a biologically-induced fractionation with light CO_2 extracted by the organism leaving a residual heavy CO_2 to form the micrite. Our observations suggest that the endolithic growth of the lichen results from two different processes: 1) Dissolution and mechanical weathering of the caliche by the fungal hyphae, and 2) precipitation of a protective surface layer of micrite. The lichen thus simultaneously dissolves the caliche substrate and biomineralizes a micrite surface. Our field observations suggest the *Verrucaria*-inhabited substrate weathers at a similar rate as uninhabited caliche.

B32C-08 1515h

Organic Sulfur Gas Production in Sulfidic Caves

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Lower Kane Cave, Big Horn Basin, WY, permits access to an environment where anaerobic sulfide-rich groundwater meets the aerobic vadose zone. At this interface microorganisms thrive on diverse metabolic pathways including autotrophic sulfur oxidation, sulfate reduction, and aerobic heterotrophy. Springs introduce groundwater rich in H_2S to the cave where it both degasses into the cave atmosphere and is used by chemautotrophic sulfur oxidizing bacteria in the cave spring and stream habitat. The cave atmosphere in the immediate vicinity of the springs has elevated levels of CO_2, H_2S and methane, mirroring the higher concentration of H_2S and methane in the spring water. The high CO_2 concentrations are attenuated toward the two main sources of fresh air, the cave entrance and breathing holes at the rear of the cave.

Conventional toxic gas monitors permit estimations of H_2S concentrations, but they have severe cross sensitivity with other reduced sulfur gases, and thus are inadequate for characterization of sulfur cave gases. However employment of a field-based GC revealed elevated concentrations of carbonyl sulfide in cave atmosphere. Cultures of microorganisms collected from the cave optimized for enriching fermenters and autotrophic and heterophic sulfate reducing bacteria each produced carbonyl sulfide suggesting a biogenic in origin of the COS in addition to H_2S. Enrichment cultures also produced methanethiol (methyl mercaptan) and an additional as yet undetermined volatile organic sulfur compound. In culture, the organo-sulfur compounds were less abundant than H_2S, whereas in the cave atmosphere the organo-sulfur compounds were the dominant sulfur gases. Thus, these organo-sulfur gases may prove to be important sources of both reduced sulfur and organic carbon to microorganisms living on the cave wall in a subaerial habitat. Moreover groundwater has not yet been recognized as a source of sulfur gases to the atmosphere, but with the abundance of sulfidic groundwater, this environment may prove to be important to the global sulfur cycle and its influence of the global radiation budget.

B32D MC: 135 Wednesday 1600h

Carl Sagan Lecture

Presiding: **D M McKnight,** INSTAAR, Univ of Colorado

B32D-01 1600h

Mars, Panspermia, and the Origin of Life: Did it begin on Earth, Mars, or Somewhere Else?

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There is no abstract available for this presentation.

B41A MC: 122 Thursday 0830h

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

Presiding: **L Gu,** University of California at Berkeley**; D Baldocchi,** University of California, Berkeley**; S W Running,** University of Montana**; R Leuning,** CSIRO Land and Water**; R Valentini,** University of Tuscia

B41A-01 0830h

FLUXNET: Distribution of a Global Network of Eddy-Covariance Flux Towers and their Role in Validating Models and Remote Sensing Products

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Currently the global network called FLUXNET consists of over 150 eddy-covariance flux-tower systems, with most flux towers operating continuously for 4 years or longer. FLUXNET (see http://daac.ornl.gov/fluxnet/) provides scientific coordination and access to consistent flux data to support global carbon cycle science. The FLUXNET database contains carbon, water vapor, sensible heat, momentum, and radiation flux measurements with associated ancillary and value-added data products. Towers are located in temperate conifer and broadleaf forests, tropical and boreal forests, crops, grasslands, chaparral, wetlands, and tundra on five continents. An analysis of the distribution of towers in the conterminous United States shows that most environmental conditions are well represented by the set of 35 towers. The combined climate, soils, and topography for each tower was compared to clusters representing groupings of similar climate, soils, and topography across the United States. The comparison identified a few combinations that were not well represented. Flux data are being used to validate ecosystem model outputs and to provide information for validating remote sensing based products, including surface temperature, reflectance, vegetation indices, LAI, FPAR, and PSN (photosynthesis) derived from the MODIS sensor on the Terra satellite. Estimates of the selected products for 8-day periods for 1-km pixels in the immediate vicinity of the flux tower are being posted on the FLUXNET Web site

for over 20 flux-towers. Modeling groups are running terrestrial biosphere models for this set of sites to compare model outputs, flux measurements, field measurements, and MODIS products.

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

B41A-02 0845h

Integrating Ecosystem Fluxes and Processes at Various Scales: the experience of CarboEurope

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Monitoring of biospheric exchanges of terrestrial vegetation inevitably is a multi-scale and multi-method exercise, requiring a high degree of both methodological as well as technical integration. In particular for carbon fluxes no single measurement method or predictive modelling tool currently exists which operates at scales from the local to the global and which covers all aspects, relevant processes and terms of the overall carbon balance. The present paper will discuss the processes and the tools we have available to integrate various temporal and spatial scales. In particular the role of flux networks will be discussed in the general framework of the terrestrial carbon observing system. As an example of such integration the CarboEurope research cluster will be illustrated

B41A-03 0900h INVITED

Present Status of AsiaFLux Network and a View Toward the Future

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The project of FLUXNET aims to quantify the spatial and temporal distribution of biospheric sources and sinks of carbon on a regional and global scale and to understand the factors that regulate net sequestration of anthropogenic CO2 through biospheric processes. From this view, FLUXNET coordinates the establishment and operation of a global network through the activities of regional networks.

The flux network activity in Japan was started under the steering committee in September, 1999. The network was named AsiaFlux, and the AsiaFlux home page (in http://www-cger.nies.go.jp/) was opened in January, 2000. Long-term measurements sites of CO2 flux in Asia are about 13 sites in Japan and Korea, about 3 -5 sites in Thailand and Siberia at present and 2 sites in China and Indonesia under planning. And, research groups of flux measurement are about 18.

AsiaFlux promotes the research potential of flux studies of carbon dioxide, water and heat flux in Japan and Asia, and will contributes to FLUXNET, especially through the results in the Asian forests under monsoon climate and specific disturbances such as biomass-burning in Asia. Also, in the lecture, several results of long-term CO2 flux measurements at AsiaFlux Sites (Takayama Site: a cool-temperate broadleaf forest, Kawagoe Site : a warm-temperate broadleaf forest and Tomakomai Site : a deciduous needle-leaf forest) are explained and compared with each other about following points; (1) Inter-annual variations of integrated uptake rate of CO2 for each month from October, 1993 to December, 1998 at Takayama Site, (2) Comparison of yearly integrated uptake amounts of CO2 at a cool-temperate deciduous forest (Takayama Site) with that at a warm-temperate deciduous forest (Kawagoe Site), (3) Differences between seasonal variation of the net CO2 exchange in a broadleaf deciduous forest and that in a larch forest.

There are several issues for the quantitative estimation of CO2 flux by the eddy covariance method. The most important factor in them may be advection effect due to topographical and inhomogeneous conditions. Almost of the sites in Asia including Japan were set in complex topographical area, therefore the analysis and estimation method of CO2 exchange under complex condition should be established through AsiaFlux activities. And, effective system for the exchanges of data in AsiaFlux and FLUXNET should be established considering these missions and the progress of data analysis in each measurement group.

B41A-04 0920h INVITED

Carbon and Water Flux Observations from AmeriFlux and Fluxnet: Some Early Results

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Flux networks provide a means for scientists to make common measurements of carbon, water, and energy exchange, to share advancements in methods, and synthesize results across the network. AmeriFlux objectives are to: Determine how environmental factors and climate regulate ecosystem CO2 and H2O exchange over the short- and long-term, evaluate impacts of anthropogenic factors, and provide data and new understanding for incorporation into models. AmeriFlux is part of the larger international network, Fluxnet. Among Fluxnet sites, we investigated seasonal and annual CO2 and water vapor exchange, and relations with environmental variables to elucidate generalities within and among biomes. The data showed a strong linkage between carbon gain and water loss, with the highest water-use efficiency values for grasslands, and lowest values for tundra. Ecosystem respiration was only weakly correlated with mean annual temperature across biomes, in spite of sensitivity within site over shorter temporal scales. Mean annual temperature and site water balanced explained much of the variation in gross photosynthesis, whereby water availability limits LAI over the long-term, and inter-annual climate variability limits carbon uptake below the potential of the leaf area available for photosynthesis. We compared BIOME-BGC model results among AmeriFlux coniferous forests, and the model showed that variation in net ecosystem carbon exchange (NEE) is mostly a function of disturbance history, with important secondary effects from site climate, ecophysiology, and changing atmospheric CO2 and nitrogen deposition.

B41A-05 0940h INVITED

OZFLUX: Water, Energy, and Carbon Cycles in Australian Terrestrial Systems

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The paper introduces the OZFLUX network which is being established to study several Australian ecosystems, discusses the analysis of eddy covariance data from tower-based flux stations, and then examines use of the flux data and a SVAT model within an atmospheric transport model to estimate regional fluxes.

Lack of energy closure by eddy covariance measurements is commonly observed for Euroflux and Ameriflux installations. Reasons for the underestimates of $H+\lambda E$ may result from the way water vapor concentrations are determined using closed-path infrared gas analyzers. A comparison of open- and closed-path analyzers show that energy closure to better than 95% can be achieved with both systems when water vapor concentrations are expressed as mixing ratios in dry air, along with careful choice of the coordinate framework and the averaging periods used to calculate fluxes.

Water, energy and carbon dioxide fluxes for two ecosystems are compared: 1) a 40 m tall, cool temperate Eucalyptus forest in SE Australia, and 2) a seasonally dry, tropical savanna woodland with sparsely arrayed, 10 m tall, Eucalyptus trees growing in a C_4 grassland, in northern Queensland. Peak carbon dioxide uptake by the tall forest in the southern winter ($T < 5°C$) is -10 μ mol m^{-2} s^{-1} compared to -2 μ mol m^{-2} s^{-1} for the savannah ($T > 20\ °C$), while evapotranspiration fluxes are similar (200 Wm^{-2}). The differences arise because grasses in the savannah are dormant at this time. Seasonal carbon uptake is greatest in the summer for the temperate forest, and during the summer rainfall period from November to March for the savannah when grasses are actively growing.

Fluxes measured at the two sites were used to test and parameterize the CSIRO Biosphere Model (CBM), which forms the lower boundary of a large-scale atmospheric transport model (DARLAM). We discuss the estimation of key parameters for CBM using ecological data on net primary production, and explain how, using a multiple-constraint approach, we may use DARLAM to estimate net fluxes at regional and continental scales. This involves constraining model predictions of fluxes and 4-D concentration fields, with measurements of fluxes, atmospheric carbon dioxide concentrations from a sparse network of towers, and surface radiances measured remotely.

B41A-06 1020h

The Manaus Dual Flux Tower Experience: Rainforest ecophysiological heterogeneities in a 10 km Scale

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Superficially rainforests appear very similar throughout the Amazon, but the region consists of a number of very distinct climatic sub-regions with very high spatial variability in species composition and physiognomy, underlined by pronounced small-scale differences in geomorphology and soils. Most FLUXNET sites represent land cover with a single tower per ecosystem type, assuming that the tower footprint encompasses a range of ecophysiological variations significantly representative of that ecosystem. In comparing two years of eddyflux data since 1999 from two LBA towers located 11 km apart on the same type of rainforest, we found striking differences in NEE (net CO2 ecosystem exchange), which could not be attributed to instrument errors or calibration problems. On analysing topography and vegetation we concluded that the flux differences could be ascribed to vegetation differences, mainly determined by areal extent of high land versus low land, which apparently leads to the definition of contrasting forest dimensions and densities. Directional NEE analysis provided additional evidence that low land waterlogged forests could be much less productive than upland forests, helping in the explanation of the differences between the towers.

Our findings indicate that the single tower-per-ecosystem (i.e. forest vs non-forest) or macro-region approach, although appropriated for low biomass and/or low diversity ecosystems, might not represent well the heterogeneities of the Amazonian rainforest in finer scales.

B41A-07 1035h

Seasonal Dynamics of Water, Carbon, and Energy Flux in Mesquite Forest: Project Overview and Preliminary Results

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Mesquite is the dominant woody plant in floodplain environments of warm deserts in the southwestern US and thus plays a central role in biogeochemical cycling and energy exchange at landscape and potentially regional scales. Our project investigates the biotic and abiotic controls over seasonal dynamics of energy exchange, CO2 uptake and release, and evapotranspiration within a mature mesquite forest on the San Pedro

River floodplain in southeastern Arizona. The growing season in the upper San Pedro River basin is punctuated by a very hot, dry period in early summer followed by monsoon rains that stimulate prolific growth of under story C4 grasses. Our general objectives are to determine the impact of summer rains on net ecosystem CO2 exchange (NEE), evapotranspiration (ET), energy fluxes and soil nutrient cycling, and to understand and model component fluxes in these two-layered canopies. We are continuously monitoring NEE and ET using an eddy covariance system mounted on a 14-m tall tower at the site. Three intensive field campaigns (pre-, mid-, and post-monsoon) included measurements of eddy fluxes beneath the mesquite canopy, mesquite sap flow, mesquite leaf area index, mesquite and grass water sources and stomatal conductance, soil moisture distribution, soil respiration, soil carbon and nitrogen pools, and isotopic composition of CO2 and water vapor within and above the canopy boundary layer. This talk will highlight some of the important findings from the first year of this project.

URL: http://www.tucson.ars.ag.gov/~russell/mesquitehome.htm

B41A-08 1050h

Seasonal Carbon Dioxide Exchange of a Grazed Grassland in California

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An new Ameriflux site was established in late 2000 to study the exchange of carbon dioxide over an oak/grass savanna and a nearby grazed grassland at the foothill of Sierra Nevada in California. Only data from the grazed grassland will be presented here. The flux measurement, along with measurements of meteorological and soil parameters, were start at the end of October 2000. Results from almost one years data indicated that most of variance of the CO2 flux can be explained by changes in soil water content and leaf area index (LAI). The grass started to growth around middle of October after receiving substantial rainfall. Midday net ecosystem CO2 exchange (NEE) increased slowly from near zero in early November to about 10 μmol m^{-2} s^{-1} (downward flux is negative) in the middle of March. While the nighttime NEE was around 1 to 3 μmol m^{-2} s^{-1}. In the spring, there was a peak growth period when photosynthesis and respiration both accelerated. The maximum LAI was 2.0, reached at this peak period. Midday NEE reached a maximum value of -18 μmol m^{-2} s^{-1}, and averaged nighttime NEE ranged from 2 to 5 μmol m^{-2} s^{-1}. Then as the soil dried out in the early summer, both daytime photosynthesis and night respiration plummeted to near zero. In the dry summer, small value of soil CO2 efflux during daytime only was observed. From almost one seasons data, we found that nighttime ecosystem respiration followed closely to the daytime photosynthetic rate, indicating the importance of photosynthetic assimilates allocation for respiration. Annual integrated carbon exchange over this grazed grassland was estimated to be around -120 g C m^{-2}. Results also show that the seasonality of NEE and growth of grasses are quite different from those mid-western grasslands.

B41A-09 1105h

Carbon, Water and Energy Fluxes in an African Savanna Ecosystem

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Eddy covariance measurements of the turbulent fluxes of CO_2, water and energy, and associated micrometeorological and biophysical measurements, have been made at a site in the Kruger National Park (KNP), South Africa, since April 2000. The study site is located in the southern region of KNP in a gently undulating landscape on granite substrate, with drainage lines 2-3 km apart and ridge tops 30-40 meters above the valley floors. The climate is semi-arid subtropical, with hot, rainy summers, warm dry winters and annual average rainfall of 550-650 mm. The soils of the catena vary between coarse-textured sand near the ridge-tops and finer-textured loamy-sand on the mid-slope and valley floors. The vegetation also differs along the catena, with broad-leaved tree species and low palatability grasses on the sandy soil and bi-pinnate tree species and more palatable grasses on the loam soils. The natural disturbance regime of the site includes fire, at return intervals of 3-8 years, as well as grazing and browsing by numerous species of wild ungulate. Results from the first 18 months of flux measurements are presented, contrasting an unusually wet growing season (1999-2000), followed by a dry-season fire, and a growing season with more average rainfall (2000-2001). The functional and phenological differences between broad-leaf and fine-leaf savanna are explored, and the carbon and water dynamics of the savanna systems interpreted in the context of seasonal weather variation, soil type and nutrient status.

URL: http://nrel.colostate.edu

B41A-10 1120h

Interannual and Spatial Variability of Carbon Fluxes and Soil Respiration Within the Understory of a Pacific Northwest Old-Growth Forest

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We present results of 3 years of long-term measurements of carbon fluxes in the forest understory at the Wind River Canopy Crane AMERIFLUX site. The Crane is located in a Pacific Northwest Old-growth Forest with trees up to 500 years old and 65 meters tall. A permanent eddy covariance station consisting of a Gill-Solent HS Research sonic anemometer and a LiCor LI6262 closed-path InfraRed Gas Analyzer (IRGA) has been operated for over 3 years at a height of 2.5 meters to complement an identical system measuring total ecosystem exchange at a height of 70 meters. A vertical profile of 8 micro-meteorological stations as well as a 3-dimensional CO2/H2O profile system provide additional data. The forest structure at the is complex with seven gymnosperm and two angiosperm tree species in the 2.3 ha. crane circle, large amounts of woody debris on the forest floor, and a diverse understory. Soil respiration is a major contributor to the carbon budget at the site. The long-term understory Eddy-covariance data indicate the release of carbon from the soil to be as large as 11 tC ha^{-1} yr^{-1} with maximum values of 6 to 8 $\mu molm^{-1}$ s^{-1}. The Net ecosystem carbon exchange (NEE) estimated by eddy-covariance is 1.5 to 1.9 10 tC ha^{-1} yr^{-1}. In this study we investigate the partitioning and temporal dynamics of carbon fluxes within the canopy. Summers can either be hot and dry (1998) or wet and relatively cool (1999). By September 1998, soils were at their driest state on record, and air temperature and atmospheric vapor pressure deficit (VPD) were both large. NEE may be significantly reduced or even turn to a net loss of carbon as water availability declines during the summer. The main period of carbon uptake is limited to the months March through May when respiration is low. Stand-level light response functions show optima for low temperatures and diffuse light conditions. In addition, we will present data and analysis on the spatial heterogeneity of understory fluxes measured by 2 additional eddy covariance systems.

B41A-11 1135h

Carbon and Water Cycles in a New Zealand Peat Bog

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Peat soils represent globally significant stores of carbon and an understanding of carbon exchange processes between peat wetland ecosystems and the atmosphere is important for understanding the effects of, and impacts upon, global climate change.

Eddy covariance measurements of CO_2, water vapour and energy fluxes were made during 1999 and 2000 at a remnant oligotrophic raised peat bog in North Island, New Zealand. The bog's hydrology has been modified by drainage of surrounding agricultural land, so that the water table is relatively deep compared to that of unmodified bogs in the region. Vegetation is dominated by two indigenous species of rush-like vascular plants belonging to the Southern hemisphere family Restionaceae.

Maximum daytime CO_2 fluxes were commonly -9 μmol m^{-2} s^{-1} and averaged -1.3 μmol m^{-2} s^{-1} over the 24-hour period in summertime. The ecosystem was a sink of atmospheric carbon for most of the year, with wintertime characterised by 12–15 weeks of carbon neutrality or slight carbon loss. Average carbon uptake by the ecosystem was 196 gC m^{-2} yr^{-1} for the two-year period. Modelling suggests that the key factor determining inter-annual variability of the carbon budget is seasonal soil temperature, whereas ecosystem respiration is relatively insensitive to the position of the lowered water table.

The bog vegetation acts as a major control over water vapour loss and energy partitioning favors sensible heat production with mean summertime Bowen ratios of approximately 2.0. Water use efficiency was highest in the morning, indicating that the vegetation maximizes CO_2 assimilation while the saturation vapour pressure deficit and transpiration rates are low. The dense canopy structure also restricts penetration of solar radiation to the peat surface, which minimizes evaporation and soil respiration.

B41A-12 1150h

Estimating Nocturnal Respiration from Profile Measurements in a Subalpine Forest

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Estimates of nocturnal respiration of forest ecosystems derived from vertical profile measurements of carbon dioxide (CO_2) concentration and wind velocity offer an effective means of supplementing, or at times, replacing eddy covariance and chamber measurements. For example, under near calm conditions, stable atmospheric stratification leads to situations in which application of eddy covariance methodology is ill-suited. An alternative approach under these conditions is to sum changes in subcanopy airspace storage and advection of CO_2 to estimate ecosystem respiration.

Profile measurements of wind velocity and CO_2 concentration were conducted in a subalpine forest (mostly lodgepole pine, ingleman spruce, and aspen) on sloping (6-7%) terrain, about 8 km east of the continental divide, northwest of Boulder, Colorado. The profiles were measured from three locations at multiple levels, ranging from 1m above ground to 33m (more than twice canopy height). All measurements were averaged over half-hour intervals. A single infrared gas analyzer, located 73m from either profile location, measured concentrations from which change in storage and advection were calculated. Under typical nocturnal conditions during the growing season (May-Sept.), katabatic winds develop near sunset and strengthen during the night reaching 0.5-0.9 m/s. Due to considerable temporal variability in wind speed and in CO_2 concentration, advective and storage fluxes were highly variable. Mid-summer concentration differences with downslope distance typically averaged about 0.1 ppm/m between heights of 1-6m. Advective flux was typically several times larger than storage flux, ranging from about 5-15 micromole/m^2/s shortly after drainage (katabatic) flow began, then decreasing through the night with temperature. On nearly calm nights during the May-August 2001 growing season, advective flux often reached about one-third the daytime uptake by the forest.

B42A MC: Hall D Thursday 1330h

Water, Energy, and Carbon Cycles in Terrestrial Systems: Measuring and Modeling From Site to Region I

Presiding: **B Law,** Oregon State University**; P Thornton,** National Center for Atmospheric Research

B42A-0106 1330h POSTER

Discriminating and quantifying root respiration into soil carbon dioxide flux of Guandaushi forest ecosystem by stable carbon isotope ratio analysis and inferred detection methods

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