samples. In this study we present two procedures : micromanipulation and FIB (Focused Ion Beam) which allow the study of microbe-mineral interfaces with TEM. The micromanipulation procedure has been presented in Benzerara et al (2003, PNAS). We have evidenced nannobacteria-like objects at the surface of the Tatahouine orthopyroxenite meteorite fallen in the tunisian desert in 1931. SEM observations suggest a complex interaction pattern between the nannobacteria-like objects, the pyroxene and microorganisms which have colonized the surface of the meteorite during its seventy years of residence on Earth. The TEM study on the very same area shows that the nannobacteria-like rods are actually well-crystallized nanometric calcite single crystals surrounded by an amorphous layer of carbonate composition. Those morphologies and structures are unusual for calcite single crystals. We discuss these observations in regard to the criteria of biogenicity i.e. biosignatures. Moreover, we examine the implications for carbonate production associated to silicate bio-weathering under aridic conditions. This work is relevant both to astrobiological and geomicrobiological issues showing that it is possible to select a microbe-mineral interface of interest at the micrometer scale, and then to prepare it for TEM observation.

B52C-06 1525h

Mapping Mineral and Microbe Interactions using Laser-based Optical and Chemical Imager (LOCI)

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Our primary focus has been development of the laser-based optical and chemical imager (LOCI) that provides optical and chemical imaging of complex, heterogeneous sample surfaces. LOCI combines a Fourier transform mass spectrometer (FTMS), unique laser-scanning system, custom optics for surface fluorescence detection, and software for automated data acquisition and analysis. A key feature of LOCI is the unique laser-scanning device that provides high spatial reproducibility true depth-profiling studies and has been automated to provide imaging capabilities. The excellent reproducibility and wavelength independence of the laser-scanning device affords the opportunity to interrogate the same sample surface via optical spectroscopy prior to obtaining mass spectra. Interpretation of mass spectra has been automated using a Fuzzy-logic inference engine, which also produces the surface maps. Our current imaging interests include characterizing heterogeneous minerals, such as basalt, with and without microbe present to determine microbial affinities for specific mineral phases. Additionally, we are interested in characterizing surface contaminant speciation.

B52D MCC: 3014 Friday 1340h

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

Presiding: **B Law,** Oregon State University**; D Baldocchi,** University of California, Berkeley

B52D-01 1340h

Recent Advances in Ecosystem-Atmosphere Interactions: an Ecological Perspective

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The atmosphere and terrestrial ecosystems are fundamentally coupled on a variety of time-scales. On short time-scales, this bi-directional interaction is dominated by the rapid exchange of CO_2, water and energy between the atmosphere and the land surface; on long time-scales, the interaction involves changes in ecosystem structure and composition in response to changes in climate that feed back through biophysical and biogeochemical mechanisms to influence climate over decades and centuries. Here, I explore some of the recent advances in our understanding of long-term ecosystem-atmosphere interactions then examine how efforts to assess the stability and resilience of ecosystem-atmosphere interactions over these long time-scales using Dynamic Global Vegetation Models are hampered by the presence of important functional diversity and heterogeneity within plant communities. Recent work illustrates how this issue can be addressed through the use of Structured Ecosystem Models that more accurately scale between the short-term physiological responses of individual plants and the long-term, large-scale dynamics of heterogeneous, functionally diverse ecosystems.

B52D-02 1400h

Partitioning Direct and Indirect Human-induced Carbon Sequestration in Managed Conifer Forests in Central Europe Using Model Simulations and Forest Inventories.

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Forest ecosystems have long been known to be an important sink in the global carbon budget. The factors responsible for the strength of the sinks and their permanence, however, are not so clear. To distinguish between direct and indirect impact on the carbon sequestration we have to work on spatial and temporal scales where humans have a major impact on the ecosystem. In this paper we contrast the effects of indirect human induced environmental changes and forest age on carbon sequestration as well as direct human induced effects on carbon accumulation such as forest management of coniferous forests in central Europe from the end of 19-th century until present. Ecosystem process model BIOME-BGC has been used to study these effects and results have been corroborated with forest inventories. We focused on conifer forests of Thuringia as a study case, because these forests are representative of central European forests and good forest inventories were available. Grouping the forests in three different strata differing in annual average temperatures and precipitation allowed us also to study the effect of elevation on carbon sequestration. Forests in all elevational strata showed an increase in vegetation carbon accumulation in all age classes as a result of environmental changes in the last 20 years (1982-2001). Young and old trees had the highest annual changes in the vegetation carbon during this period. Under pre-industrial conditions, trees older than 80 years showed almost no annual increase in vegetation C carbon accumulation. With industrial climate scenario those trees were still carbon sinks. Trees older than 100 years in the low elevations were an atmospheric carbon source in the pre-industrial case, but carbon sinks in the industrial case. Nitrogen-deposition had the highest impact on the net ecosystem production (NEP) for the high and middle elevations, whereas CO_2 fertilization was most responsible for NEP changes in the low elevations. Under current environmental conditions, the total modeled carbon accumulation in the coniferous forests of Thuringia was estimated at 2.09 t C $ha^{-1}y^{-1}$ with an averaged annual NEP of 1.78 t C $ha^{-1}y-1$ and net biome production (NBP) of 1.12 t C $ha^{-1}y^{-1}$. Once corrected with the actual forest harvest statistics, the modeled NBP estimate was reduced to 0.83 t C $ha^{-1}y^{-1}$. Under pre-industrial conditions the NBP estimates were 0.43 and 0.15 t C ha-1 y-1 respectively. The environmental changes led to the sink strength of 62% or 82% depending on how the harvest was estimated. Based on the estimates of annual accumulated vegetation carbon (NBP_{VEG}), the forest inventory data gave NBP_{VEG} varying from 0.45 to 2.6 t C $ha^{-1}y^{-1}$ depending on the method used for estimating the wood increments. The modeled NBP_{VEG} was estimated at 1.42 t C $ha^{-1}y^{-1}$. Environmental changes or indirect human impact resulted in 44% increase in modeled vegetation carbon accumulation of conifer forest in Thuringia. From the forest inventory data we estimated the effect of changing area of the forest age classes, or the direct human impact on the carbon sequestration, to be approximately 37%.

B52D-03 1420h

The Effects of Shading and Diffuse Radiation in Estimating Carbon and Water Fluxes in Tropical and Midlatitude Sites

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The interactions between radiation, water, and carbon are a crucial component in determining terrestrial carbon and water fluxes. In this paper, we will present evidence to demonstrate the close relationship between these processes in an integrated climate system using the Simplified Simple Biosphere Model (SSiB, Xue et al., 1991). The SSiB implemented Collatz et al' (1991, 1992) parameterizations of plant photosynthesis and stomatal conductance to consider CO2 assimilation of vegetation. Quasi-analytical solutions of these parameterizations were developed (Zhan et al., 2003) to improve the computational efficiency and to produce stable solutions for long-term simulations in GCMs and regional models. We tested this enhanced SSiB using observational data from LBA, Boreal, and AmeriFux sites. The results indicated that the model in general produced a higher than normal rate of photosynthesis which led to an overly large transpiration. We examined model performance and found that this was mainly caused by the scaling methodology. In our earlier approach described above, the sunlit and shaded leaf areas were not considered. Furthermore, only direct radiation effect was included in the scaling equation, which was adapted from SiB2. Diffuse radiation, which arises from atmospheric scattering and from scattering within the canopy, has been shown to have a crucial role in the photosynthetic process (e.g., Norman, 1982; Baldocchi, 1997). Therefore, we developed a new parameterization for shading and scaling to more realistically simulate the land/atmosphere interaction processes. The shading parameterization is based on Norman's approach (mainly relies on solar zenith angle), but we further take vegetation properties and solar radiative transfer property within canopy into consideration. The scaling method considers the effects of both direct and diffuse radiations. We have tested the new method using the observational data from the LBA experiment (2000) and the Boreal experiments (1996). This new method substantially improved the simulations of daily mean carbon and water fluxes and their diurnal variations, especially in the tropical area. For example, in the LBA experiment, the root-mean-square (RMS) error for the latent heat flux and the carbon flux are 15.1 w m-2 and 2.9 mmol m-2 s-1, respectively, which are much smaller than the RMS error 45.4 w m-2 and 12.7 m mol m-2 s-1 in the simulation with the old method. Experiments are also conducted to comprehensively test the effects of soil moisture, diffuse radiation, and vegetation properties in estimating the variability of carbon and water fluxes.

B52D-04 1440h

Old and Not-So-Old: Examining Changes in Forest Ecosystem Carbon Exchange With Stand Age in the Upper Midwest U.S.

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Forest stand age is an important determinant of ecosystem carbon uptake. Though there are biometric measurements and ecological models for forests of all ages, there are few stand-scale eddy-flux measurements of net carbon exchange in older forests, though the number is increasing. In order to scale carbon fluxes from sites to regions, where stands of multiple ages may exist, it is necessary to measure to the effect of stand age on carbon exchange. Measuring the effect of stand age on carbon exchange is also necessary when trying to predict future or past carbon exchange (scaling across time). Many researchers have noted that site disturbance history is the fundamental factor in determining carbon uptake by forests over time scales of

decades to centuries. The 8,500 ha Sylvania Wilderness in the upper peninsula of Michigan is one of several large tracts of old-growth forest in the Midwest. Trees range from 0-350 years old. Primary species are sugar maple, eastern hemlock and yellow birch. Catastrophic disturbance is rare. A research plot near the wilderness was established in late 2001 to measure the net ecosystem exchange (NEE) of carbon and water using eddy-flux, component flux and biometric methods. This site is part of the Chequamegon Ecosystem Atmosphere Study (ChEAS, http://cheas.psu.edu), a loose affiliation of researchers conducting carbon and water research in northern Wisconsin and upper Michigan. Another similar research plot within ChEAS and not far from Sylvania is the Willow Creek mature uplands site. This forest is about 70 years old and the primary species are sugar maple, basswood and green ash. The site had presettlement old-growth vegetation similar to what is currently seen in the Sylvania Wilderness. Thus, the carbon exchange seen at Sylvania may be representative of carbon uptake at Willow Creek had it not been logged in the early 20th century, and may also represent the future (or past) carbon uptake for similar forests in northern Wisconsin/upper Michigan. Initial results from 2002 show that both Sylvania and Willow Creek were sinks of carbon, though the annual NEE of carbon at Sylvania was only -72 gC/m2/yr, while it was -447 gC/m2/yr at Willow Creek. The lack of carbon balance at the old-growth site may be caused by growth enhancement due to carbon/nutrient fertilization, climate warming, or recent local-scale disturbances. A standard moving-window Arrenhius-style temperature-nighttime NEE relationship was used to separate total ecosystem respiration from gross ecosystem production (GEP). Total annual respiration was much greater at Sylvania (965 gC/m2/yr) than Willow Creek (667 gC/m2/yr), while GEP at Sylvania (1045 gC/m2/yr) was only slightly smaller than Willow Creek (1136 gC/m2/yr). The largest differences in respiration between the two sites occurred in early summer, whereas the largest difference in GEP occurred in late summer. The observed differences between the two sites matches well with theory. Ecosystem respiration is expected to increase steadily with stand age while gross ecosystem production is expected to increase rapidly as new species are established, but eventually level off. Current ongoing component flux measurements will help determine the mechanisms for the observed differences in carbon uptake at the two sites and provide insight on the causes of declining carbon exchange with stand age.

B52D-05 1455h

Pulse Effects of Soil Respiration After Rain Events in California

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We observed pulse effects of soil respiration following the first rain and second rain after the dry season in California savanna and forest ecosystems in 2002 and 2003. Soil respiration was measured by three different methods: soil CO2 profile measurements using solid-state CO2 sensors buried in several depths of soils, under-story eddy covariance measurements, and chamber measurements. In addition, we conducted laboratory soil incubation experiments and in situ watering experiments to simulate rain events to observe the pulse effects of soil respiration. The results indicated that soil microbes immediately responded to the rain events. The time lag is less than an hour. The pulse CO2 efflux was about 5-10 times larger than the efflux before the rain. Spatially, soil respiration under trees has smaller pulse than that in the open area. Surface soils provide more CO2 sources and more contribution to the pulse than deep soils. The pulse after the first rain was more significant than that after the second rain, probably due to the decrease in the labile carbon content. The pulse effects also influence the seasonal pattern of soil respiration. It is suggested that soil respiration models may need to consider these pulse effects of soil respiration.

B52D-06 1510h

Annual CO2 budget at arctic wet sedge tundra in Barrow and the contribution of winter fluxes

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Although the longer winter period in the arctic affects annual CO2 budget, there have been few direct flux observations because of the sever climate. We measured CO2 and energy fluxes by eddy correlation technique and the micrometeorology at wet sedge tundra in Barrow, Alaska from 1999 spring. The data obtained continuously provided huge upward fluxes during snow-covered period, which occurred during blizzard events. The measured upward fluxes during the strongest blizzard event in mid winter showed CO2 source of 198 g CO2 m-2, 12 MJ/ m-2 and16 MJ/ m-2 for sensible and latent heat fluxes. If the fluxes were facts, which might be large contributions on annual carbon and energy budgets. We analyzed the fluxes and the micrometeorology detailed and revealed that the upward fluxes in mid-winter resulted in sublimation during blizzard, thus the huge upward fluxes in winter were thought to be apparent, especially CO2 efflux was thought to be unpractical flux converted from carbonic acid in the snow. Average winter respiration between 1999-2002 (upward CO2 flux during October to May) was around 55 gC m-2 which was almost the same as ecosystem respiration during the growing period (June-September). The annual CO2 budget was sink of 16-102 gC m-2, in which the large deviation among three years resulted in different CO2 sink levels in growing periods caused by different climate in each year.

B52D-07 1525h

Evidence of a Positive Warming Effect on Boreal Productivity Derived From a 11-year Air CO2 Concentration Record at Fraserdale

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An 11-year long (1990-1996, 1999-2002), hourly air CO_2 concentration record measured on a 40-m tower at Fraserdale, northern Ontario, is used to retrieve information on the carbon cycle of boreal ecosystems at the landscape level. Using a model, the effects of ecosystem metabolism and atmospheric diffusion on the hourly CO_2 concentration are separated, and daily ecosystem respiration (R_e) and gross primary productivity (GPP) are estimated. Both R_e and GPP increased with increasing air temperature. As the mean air temperature in the growing season (May to October) varied from 10.6 to 13.2°C within the 11-year period, seasonal mean GPP varied from 3.4 to 5.3 gC $m^{-2}d^{-1}$ and R_e from 3.2 to 3.9 gC $m^{-2}d^{-1}$. The temperature sensitivity is higher for GPP than for R_e because of additive direct and indirect warming effects on productivity. Faster nutrient mineralization in soil at higher temperatures is considered to be the main indirect factor according to model simulations. As the footprint area of the concentration measurements is of the order of 10^2-10^4 km^2, the methodology allows for evaluation of the collective effects of climate change on ecosystems at the landscape level consisting of forests of different ages, species and densities as well as non-forest cover types. The atmospheric diffusion model only considers the vertical diffusion processes in the surface and mixed layers in both daytime unstable and nighttime stable conditions. In hourly simulations, such a model is in error under advection conditions associated with synoptic weather systems, but when averaged for ten-day periods, the error in the simulated CO_2 is less than 0.6 ppmv. The methodology of deriving fluxes from concentration was tested against a tower flux site in a black spruce forest in Saskatchewan for the year 1998. The correlation coefficient was 0.86 between concentration-derived daily GPP and those derived from eddy covariance flux measurements. When averaged for 10 days, the coefficient increased to 0.94.

URL: http://www.geog.utoronto.ca/info/facweb/Chen/Chen%27s%20homepage/home.htm

B52E MCC: 3014 Friday 1600h

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

Presiding: **M Falk,** University of California, Berkeley**; J Wang,** Massachusetts Institute of Technology**; P Thornton,** National Center for Atmospheric Research

B52E-01 1600h

The Influences of Fresh Water co2 Effluxes and Mesoscale Circulations on Regional Carbon Balance in the Tapajos Region, Para, Brazil

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We have investigated mesoscale variations of atmospheric co2 over a heterogeneous landscape of forests, pastures, and large rivers during Santarem Mesoscale Campaign (SMC) during August 2001. We simulated the variations of surface fluxes and atmospheric concentration of co2 using the CSU Regional Atmospheric Modeling System (RAMS) on 4-level nested grids which including a 1-km finest grid centered on the Flona Tapajos. Surface fluxes of co2 were prescribed in the model using idealized diurnal cycles over forest and pasture vegetation, and over surface water using a value suggested by in-situ measurements in the Amazon River. Heterogeneous vegetation types were derived from the 1-km International Geosphere-Biosphere Programme (IGBP) land-cover dataset version 2.0. Our simulation ran from 1 through 15 August 2001, which was concurrent with our SMC. The results demonstrated that the local topography, the roughness length, the "T" shape juxtaposition of Amazon and Tapajos Rivers, and the resulting horizontal and vertical wind shears, all facilited the generation of local mesoscale circulations. The explanation for the mechanisms producing the lower level convergence line on the east bank of Tapajos River during the strong trade-wind days will also be presented. Meanwhile, we investigated the effects of surface water co2 effluxes on the regional carbon balance. The simulations with and without specifying co2 fluxes from the rivers and inundated land were performed. The result demonstrated that surface water co2 fluxes modify simulated co2 concentrations, especially at night. We are currently collecting and processing SMC measurement data, and hope that our modeling study can help the interpretation of [co2] distribution observed by towers and light aircraft.

B52E-02 1615h

Assimilation of Remotely Sensed Data into the Biome-BGC Ecosystem Model to Improve the Prediction of Energy and Carbon Exchange in Southwestern Mountain Island Forests

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