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The global carbon assessments have suggested that the mid-latitude forests are likely the primary places where carbon sequestration has been enhanced because of increasing anthropogenic N deposition. In this paper, we examine the idea with a regional study of the U.S. mid-Atlantic and present the estimate produced by a dynamic and process-based forest ecosystem model, PnET-CN. For the U.S. mid-Atlantic region, forests cover about 56% of the total land area. The pattern of N deposition varies across the region because of complicated landscape features and land-use types. High wet deposition generally occurs in the northern lake and high elevation areas, as well as urban/suburban especially metropolitan areas. The N deposition data used for the modeling were from the 1999 scenario that was generated by a research group at Penn State University using interpolation algorithms based on concentration data collected at National Atmospheric Deposition Project / National Trends Network monitoring sites and precipitation data from a denser network of National Atmospheric and Oceanic Administration Cooperative climatic sampling sites. We assumed that N deposition in 1930 was about 25% of the 1999 level and interpolated this level linearly back to 1930 for each 1-km square pixel within the region. Our simulations based on the ramped N increase and controlled N level in the past 70 years indicate that the growth effect of a sustained increase of N deposition could vary in different locations and forest types. For example, some mountain coniferous forests are likely N saturated and the increased N deposition had little effect on forest growth. Deciduous forests in the region seemed to respond more positively to N deposition. The annual growth rate could be up to 4.7% higher after a long-term exposure to additional N inputs. It is unclear what is the threshold in which additional nitrogen may degrade forest ecosystem function in terms of reducing net photosynthesis, N use efficiency and forest growth. The results reported here are only preliminary because (1) we only simulated the growth impacts from additional wet N deposition due to the lack of dry deposition data, and (2) the assumption of a ramped increase of N deposition may fail to count the growth effect of inter-annual variations of N deposition that can change tremendously in wet and dry years. The modeling results will be improved along with our on-going research and new data.

#### B51B-0213 0830h POSTER

##### Testing watershed size and slope, soil C:N and carbon storage as indicators of riverine dissolved organic carbon concentration and export

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Several predictors of riverine dissolved organic carbon export have been presented over the last decade. The relationship between dissolved organic carbon export and a) watershed size and slope, b) mean watershed carbon storage and c) mean biome soil C:N ratio have all had measurable success as predictors of riverine DOC export. We tested each of these major predictors within a cool temperate conifer biome in Nova Scotia and New Brunswick, Canada. Soil cores were taken from thirteen watersheds, and the organic and mineral soil horizons were analyzed for carbon and nitrogen. The number of soil cores taken from each watershed depended on the size of the watershed. We retrieved 12 cores from the smallest and 35 from the largest watersheds. Bulk density was calculated for each soil sample so that watershed carbon storage could be derived. Watershed area, forest cover, slope and altitude were also logged for each soil sample point.

Watershed size ranged from  $6.3 \times 10^3$  ha to  $1.25 \times 10^5$  ha. Altitude from 88 to 1458 ft. Individual soil C:N ratios ranged from 16.5 to 48.9 in organic soil horizons and from 6.1 to 29.8 in mineral soil horizons. Dissolved organic carbon export for each of the watersheds was calculated and range between 29.9 and 123.5 kg DOC  $\text{ha}^{-1} \text{yr}^{-1}$ . Ten watersheds were used to derive empirical relationships between DOC export and each of aforementioned major predictors of DOC export. The remaining three watersheds, not included in empirical modeling were used for testing each model.

#### B51B-0214 0830h POSTER

##### Nitrogen and Carbon Cycling in Deforested and Pristine Upland (2400m) Forest Catchments in the Peruvian Andes

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Nitrogen and carbon cycling were examined within two upland (2400m) forest catchments in the Peruvian Andes. One catchment was partially deforested within the last 3 years, while the other has remained untouched. Tracer amended samples were analyzed to determine the pathways and rates of nitrogen cycling in streams draining each catchment. Both streams exhibited very low inorganic nitrogen levels, on the order of 1 to 2  $\mu\text{M}$ . A large percentage ( $>1/3$ ) of the total fixed nitrogen flux from these systems was in the form of particulates. Preliminary results suggest a very high rate of nitrogen cycling in these systems. Isotopic measurements of plant samples from both catchments also suggest that these forests are highly efficient in trapping and using atmospheric nitrogen sources. The partially deforested catchment had significantly more species using C4 and CAM carbon fixation pathways. Leaf litter from both streams and leaves from trees in the area were also analyzed for carbon and nitrogen isotopes to compare and contrast nitrogen and carbon cycling between the two sites. This and other data to be presented suggest that deforestation has subtle but significant effects upon the ability of tropical upland forests to retain and use nutrients.

#### B51C MC: 122 Friday 0830h

##### Water, Energy, and Carbon Cycles in Terrestrial Systems: Measuring and Modeling From Site to Region II (joint with H)

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

#### B51C-01 0830h

##### Assessing Interannual Variation in Net Ecosystem Production over a Coniferous Forest Landscape

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Spatial estimates of net ecosystem production (NEP) can be attained by constraining ecosystem process models with remote sensing and hierarchical plot data (intensive measurements and survey data). In temperate coniferous forests, NEP varies widely 1) over the course of secondary succession, 2) in response to environmental gradients associated with elevation, and 3) in response to interannual variation in climate. These factors should therefore be included in spatially explicit estimates of NEP that are of interest in relation to assessing current biologically driven carbon flux. In the Pacific Northwest (PNW) region we are using a combination of satellite remote sensing, gridded meteorological data, and ecosystem process models to account for these factors. The Landsat ETM+ sensor,

with a spatial resolution of about 30 m, generally captures the scale of the spatial heterogeneity associated with disturbances such as fire and logging. In PNW forests, ETM+ can resolve multiple age classes, and multiyear analysis that employs change detection permits dating of clearcuts generated since the 1970s. This fine temporal resolution early in succession is important because of the rapid changes in NEP with stand age. ETM+ is also effective in mapping leaf area index, although the algorithms tend to be asymptotic at the high LAIs found in some coniferous forests. Multiyear gridded meteorological data, based on interpolated meteorological station observations, provides the basis for model spin ups which bring simulated soil organic matter pools into near equilibrium with the local climate. Opportunities for validating NEP surfaces or component fluxes include georeferenced forest inventory data for bole wood carbon storage and production, eddy covariance flux data for daily gross primary production and net ecosystem exchange, and chronosequence studies in a variety of bioclimatic zones for characterizing carbon pools and fluxes over succession. Results of multiyear simulations at landscape to regional scales will help in understanding biospheric responses to climatic phenomena such as ENSO events.

#### B51C-02 0850h

##### Inverse Modelling of Carbon and Oxygen Isotopic Discrimination During CO<sub>2</sub> Assimilation Within a Forest Canopy

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Inverse modelling techniques were used with a Lagrangian model of turbulent dispersal to infer vertical profiles of carbon and oxygen isotope discrimination during photosynthesis from concentration measurements within a Siberian coniferous forest canopy. Profiles of leaf-level fluxes of CO<sub>2</sub>, H<sub>2</sub>O and heat, as well as ground fluxes, were also determined.

Concentrations of five scalar quantities, CO<sub>2</sub>, <sup>13</sup>CO<sub>2</sub>, C<sup>18</sup>O<sup>16</sup>O, H<sub>2</sub>O and temperature, were measured at up to nine heights within and above a mixed fir and spruce forest in central Siberia over several days during snow melt in May 2000. Eddy covariance measurements of CO<sub>2</sub>, H<sub>2</sub>O and heat fluxes were made above the canopy over the same period, providing independent verification of the model flux estimates.

Photosynthesis, transpiration, heat loss and isotope discrimination during CO<sub>2</sub> assimilation were modelled for sun and shade leaves throughout the canopy through a combination of inversion of the concentration data and principles of biochemistry, plant physiology and energy balance. Parameters relating to photosynthetic capacity, stomatal conductance, radiation penetration and turbulence structure were optimised simultaneously by the inversion to provide the best fit of modelled to measured concentration profiles of the five scalars.

A sensitivity analysis was undertaken to determine the robustness of the parameter solutions. Different parameter combinations were investigated to extract the maximum possible information from the available data with the highest confidence levels for optimised parameter values. Parameters that were not sufficiently independent were assigned best-guess values and the model error resulting from uncertainty in these estimates was investigated.

Modelled carbon isotope discrimination from the snow-melt period was lower than has previously been measured or modelled for boreal ecosystems, corresponding to low intercellular CO<sub>2</sub> concentration and stomatal conductance, both decreasing significantly during the day. The effect of low temperatures and high viscosity of water on plant hydraulics may explain these low values. Modelled oxygen isotope discrimination was consistent with other estimates for boreal regions. There was no clear trend with time of day because of the conflicting influences of vapour pressure deficit. This increases during the day causing an

increase in isotopic enrichment of leaf water (increasing daily trend in  $^{18}\text{O}$  discrimination) but also causes stomatal closure and a corresponding decrease in intercellular  $\text{CO}_2$  concentration (decreasing daily trend).

Modelled total above-canopy  $\text{CO}_2$ ,  $\text{H}_2\text{O}$  and sensible heat fluxes compared well with eddy covariance measurements when a stability correction was applied to early morning and late evening profiles. The partition between soil and canopy fluxes found by the model suggested that soil respiration was relatively constant at around  $2 \mu\text{mol m}^{-2}\text{s}^{-1}$ , soil evaporation was close to the equilibrium rate and soil heat flux was negative (downwards) due to the thawing ground.

#### B51C-03 0905h

##### Modeling the effects of disturbance history and climate on carbon and water budgets in evergreen needleleaf forests

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The effects of disturbance history, climate, and changes in atmospheric  $\text{CO}_2$  concentration and nitrogen deposition on carbon and water fluxes in seven North American evergreen forests are assessed using canopy-scale flux observations and descriptions of the vegetation type, management practices, and disturbance histories at each site. An ecosystem process model integrating the effects of interannual climate variability, disturbance history, and vegetation ecophysiology (Biome-BGC) is used to estimate carbon and water fluxes and storage, with results compared to site biometric analyses and eddy covariance observations aggregated by month and year. Model leaf area index compared well with observations across a wide climate gradient. Model ET compared reasonably well with observations, except for problems related to evaporation from wet canopies, where known instrument biases make the interpretations difficult. There is a fundamental discrepancy between model and observed NEE at three sites, and large seasonal differences at most sites: the model estimates a warm-season net sink that is much smaller than observed. Various lines of reasoning are explored to help explain this discrepancy. Model results suggest that long-term variability in net ecosystem exchange of carbon (NEE) is largely a function of disturbance history and changes in  $\text{CO}_2$  and N deposition, with short term variability due to climate variation as filtered by vegetation ecophysiology. Disturbance recovery responses in NEE depend on disturbance type and intensity, and for harvest disturbances, on post-harvest management practices such as burning, fertilization, and replanting. The modeled effects of increasing  $\text{CO}_2$  on NEE are generally limited by N availability, and are greatly increased after disturbance due to increased N mineralization and reduced plant N demand.

#### B51C-04 0920h

##### Seasonal and synoptic patterns of $\text{CO}_2$ fluxes and mixing ratios from FLUXNET sites

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Regional and continental-scale net ecosystem-atmosphere exchange (NEE) of  $\text{CO}_2$  is difficult to determine at time-scales of days to years with existing data. Tower-based eddy-covariance fluxes describe local-scale ( $\sim 1 \text{ km}^2$ ) fluxes over a wide range of time scales. Transport models and atmospheric mixing ratio data can be used to derive global and hemispheric fluxes at annual to seasonal time scales. Mixing ratio data over land, however, is lacking, and uncertainty about the vertical profile of  $\text{CO}_2$  in the troposphere limits our ability to interpret existing surface-based data.

Tower-based observations that include both  $\text{CO}_2$  mixing ratio measurements and eddy-covariance flux

measurements can lend insight into NEE at these intermediate spatial and temporal scales. Surface layer data can be used to estimate both atmospheric boundary layer (ABL) and lower tropospheric  $\text{CO}_2$  mixing ratios. Tall tower and airborne  $\text{CO}_2$  profiles show that this is valid. Annual, seasonal and synoptic gradients in  $\text{CO}_2$  are clearly determined from surface-based data.

The existing limited network of sites in N. America and Europe that measure both well-calibrated  $\text{CO}_2$  mixing ratios and eddy-covariance fluxes are used to investigate synoptic and seasonal-scale patterns in  $\text{CO}_2$  fluxes and mixing ratios. Synoptic patterns are evident at a continental scale, but the sign of  $\text{CO}_2$  advection varies with season and air mass history. Changes of up to 15 ppm in ABL  $\text{CO}_2$  coincide with frontal passages. The seasonal land-ocean ABL mixing ratio gradient peaks at about 10 ppm and is similar across continental sites. Advection and NEE of  $\text{CO}_2$  are both required to explain the large time lags between the seasonal cycles of NEE, and oceanic and land ABL mixing ratios. Climatic anomalies are evident in inter-seasonal comparisons of NEE of  $\text{CO}_2$ , and are coherent across continental scales. These anomalies are evident in continental ABL  $\text{CO}_2$  mixing ratios. These results illustrate potential applications of an extended network of coupled continental  $\text{CO}_2$  flux and mixing ratio observations.

#### B51C-05 0935h INVITED

##### Modeling the Interactive Effects of Multiple Environmental Stressors on Regional Forest Carbon Dynamics in the Northeastern U.S.

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Temperate forests are increasingly affected by a variety of environmental factors that stem from human industrial and agricultural activities. In the northeastern U.S., important environmental change agents include tropospheric ozone, atmospheric nitrogen deposition, elevated  $\text{CO}_2$ , and historical human land use. Although each of these has received attention for its individual effects on forest carbon dynamics, integrated analyses that examine all factors simultaneously are rare. To examine the relative importance of all of these factors on current forest growth and carbon exchange in the northeastern U.S., we included them individually and in combination in a forest ecosystem model (PnET-CN) that was applied to sites where ambient ozone concentration data were available from air quality monitoring stations and where other inputs could be obtained from existing regional data sets. The model was parameterized to represent typical northern hardwood forest stands and run for each site from 1700 to 2000 under different scenarios of air pollution and land use history.

Results suggest that historical increases in  $\text{CO}_2$  and N deposition have stimulated forest growth and carbon uptake, but to different degrees following agriculture and timber harvesting. These differences resulted from the effects of each land use scenario on predicted soil C and N pools and the resulting degree of growth limitations by carbon versus nitrogen.

Including the effects of tropospheric ozone on canopy photosynthesis offset the predicted growth increases substantially; by an amount roughly equivalent to the fertilization effect of N deposition. This result is particularly relevant given that ozone pollution is widespread across much of the world and because broad-scale spatial patterns of ozone and nitrogen deposition are coupled through the dependence of ozone formation on nitrogen oxide emissions. This was demonstrated across our study region by a significant correlation between ozone exposure and rates of N deposition. The broader implication of this result is that a reduction of N-induced carbon sinks by ozone may be a common phenomenon globally.

#### B51C-06 0955h

##### Assessing the Net Carbon Balance of Western Siberia: Results from the EUROSIBERIAN CARBONFLUX Project (1998-2000)

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EUROSIBERIAN CARBONFLUX (1998-2000) constitutes a feasibility study for the development of an observing system to quantify the net regional (1-2000 km) and continental scale carbon balance of western Siberia and Eastern Europe and its variation from year to year. This goal is addressed by means of an integrated top-down and bottom-up approach consisting of: (1) Continuous surface flux measurements of  $\text{CO}_2$  in key ecosystems at 2 locations in Western Russia (Fyodorovskoye, 56N, 33E), and Central Siberia (Zotino, 60N, 90E). (2) Regular (every 2-4 weeks) vertical profile measurements in the lower troposphere with light aircraft of the concentration of  $\text{CO}_2$  and other carbon cycle relevant tracers (carbon and oxygen isotopes,  $\text{CO}$ ,  $\text{CH}_4$ ,  $\text{O}_2/\text{N}_2$  ratio) at 3 locations (Fyodorovskoye, 56N, 33E, Syktyvkar, 62N, 53E, and Zotino, 60N, 90E) along a West-East zonal gradient across Russia. (3) Development and implementation of a continental scale meteorological and biogeochemical-model framework for determination of net carbon balance of the study region by means of forward and inverse model simulations. Up to now almost three years of data have been obtained, documenting (1) the interannual climate impact on surface fluxes and (2) the seasonal cycle and mean annual gradients of the atmospheric carbon tracers in the planetary boundary layer and the overlying free troposphere in the interior of the Eurasian continent. The developed modeling system consists of a global transport model with a nested meso-scale atmospheric model over boreal Eurasia, linked to a surface model of carbon exchange fluxes based on remote sensing data (NDVI). Starting in 2002, the observing system will be expanded in a follow-up project to Eastern Siberia, the northern Eurasian tundra and the Mongolian grasslands.

URL: <http://www.bgc-jena.mpg.de/~martin.heimann/eurosiob>

#### B51C-07 1030h

##### Atmospheric Constraints on Terrestrial Exchanges at the Regional to Continental Scales

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Exchanges of carbon, water, and energy between the terrestrial ecosystem and the atmosphere impart their signatures on the atmospheric distribution of the corresponding tracers— $\text{CO}_2$ ,  $\text{H}_2\text{O}$ , and temperature. Transport in the atmosphere carries and integrates signals of ecosystem exchange present in the tracer distributions over large spatial scales. Thus measurement and analysis of atmospheric tracers provide estimates of large-scale ecosystem fluxes. We present aircraft observations of  $\text{CO}_2$ ,  $\text{H}_2\text{O}$ , and temperature over the U.S. from the  $\text{CO}_2$  Budget and Rectification Airborne (COBRA) study and demonstrate how such measurements allow for quantification of  $\text{CO}_2$ , water, and sensible heat fluxes at regional to continental scales. A tool for modeling atmospheric transport back in time is used to link observations with ecosystems upstream of the measurement location. Inverse analyses are applied to optimize for ecologically relevant parameters. We discuss the value of aircraft observations in providing "top-down" constraints on large-scale ecosystem exchanges which can be directly compared with "bottom-up" estimates.

## B51C-08 1045h INVITED

Mesoscale Modeling of  
Vegetation-Atmosphere Feedbacks

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The data collected as part of the Large-scale Biosphere Atmosphere (LBA) Experiment in Rondonia, Brazil and the data collected in central US as part of the GCIIP program are used together with the Regional Atmospheric Modeling System (RAMS) to investigate the vegetation-atmosphere interactions at the different scales in these two different geographical locations. In both cases, the atmospheric boundary layer developing above various land covers is very different, sometimes creating horizontal pressure gradients strong enough to generate organized mesoscale circulations, which affect the structure of the boundary layer, clouds and precipitation. In a parallel investigation, three scenarios were produced with the Goddard Institute for Space Studies (GISS) GCM: (1) current climate using current land cover; (2) current climate with no deforestation in the Amazon basin; and (3) current climate with a mixture of pasture and brush in most of the Amazon basin. For each scenario, six realizations of 12-year runs were produced. Different statistical tests are used to demonstrate the effect of land-cover change in the Amazon on the regional climate of other continents. Particular attention is paid to the effects at the seasonal time scale. Teleconnections are clearly identified between the Amazon and North America, indicating that deforestation in the Amazon reduces the summer precipitation in central North America, and reduces fall precipitation in south-west North America.

## B51C-09 1105h

Regional differences in carbon  
source-sink potential in the USDominique Bachelet<sup>1</sup> (360-753-7728;  
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We used the dynamic vegetation model MC1 to simulate the change in carbon storage potential under historical conditions (1895-1994) in the 6 regions of the conterminous USA delineated for the USGCRP National Assessment. The largest variations occur in the Midwest where large fire events (1937, 1988) affect vegetation biomass. The Southeast shows decadal-type trends and alternates becoming either a carbon source (1920's, 1940's, 1970's) or a sink (1910's, 1930's, 1950's). The drought of the 1930's is most obvious in the creation of a large carbon source in the Midwest and the Great Plains. The two most western regions and the northeast show the smallest amplitudes in their variations. Projections into the future using the CGCM1 climate scenario show the Northeast becoming mostly a carbon source, the Southeast becoming the largest carbon source in the 21st century, and the two western-most regions becoming carbon sinks in the second half of the 21st century. Regional trends in C storage under historical conditions show an increase in soil organic matter with time except in the Midwest which starts losing carbon in the 1900's but starts recovering it by the 1970's. The Pacific Northwest shows a less pronounced decline in soil C but that continues through the 1980's. Projections into the future show increases in soil organic matter in the Great plains and the two western-most regions, decreases in the Midwest and the Northeast, and a huge decline in the Southeast soil carbon levels with respect to the 1895 level.

## B51C-10 1120h INVITED

Global and Regional Constraints on  
Exchanges of CO<sub>2</sub> Between the  
Atmosphere and Terrestrial BiosphereStephen C Piper (1-858-534-4230 x12;  
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The vigorous atmospheric circulation rapidly mixes CO<sub>2</sub> that is exchanged with the terrestrial biosphere and oceans. Therefore, at time scales greater than 1 year, the approximate interhemispheric exchange time of the atmosphere, an average of CO<sub>2</sub> measurements from a network of surface stations can be used to accurately determine the global net change in atmospheric

CO<sub>2</sub>. By subtracting CO<sub>2</sub> produced by fossil fuel combustion, which is well characterized by national statistics, the global net sum of terrestrial biospheric and oceanic net fluxes, here termed the "nonfossil" CO<sub>2</sub> flux, can also be accurately determined. The nonfossil CO<sub>2</sub> flux averaged -2.1±0.3 PgC/yr and -3.2±0.4 PgC/yr in the 1980s and 1990s respectively (negative denotes out of the atmosphere), and varied in annual average from about 0 to -4 PgC/yr over these two decades.

Two primary methods have been used to further partition the nonfossil CO<sub>2</sub> flux between land and oceans: the O<sub>2</sub> and <sup>13</sup>C/<sup>12</sup>C methods, which rely, respectively, on measurements of atmospheric O<sub>2</sub> (actually O<sub>2</sub>/N<sub>2</sub> for technical reasons) and of the <sup>13</sup>C/<sup>12</sup>C ratio of CO<sub>2</sub>. Burning of fossil fuel consumes atmospheric O<sub>2</sub> and releases CO<sub>2</sub> with a <sup>13</sup>C/<sup>12</sup>C ratio lower than that of atmospheric CO<sub>2</sub> whereas uptake of CO<sub>2</sub> by terrestrial plants releases O<sub>2</sub>, and increases the atmospheric <sup>13</sup>C/<sup>12</sup>C ratio owing to the preferential assimilation of <sup>12</sup>CO<sub>2</sub> relative to <sup>13</sup>CO<sub>2</sub>. In contrast, the uptake of CO<sub>2</sub> by the oceans has little effect on either the atmospheric O<sub>2</sub> or <sup>13</sup>C/<sup>12</sup>C ratio. Therefore, the net CO<sub>2</sub> uptake or release from the terrestrial biosphere can be calculated in either method by subtracting the change owing to fossil fuel emissions from the measured change in the atmosphere, utilizing known stoichiometric ratios of O<sub>2</sub> and CO<sub>2</sub> in the O<sub>2</sub> method, and isotopic fractionation factors in the <sup>13</sup>C/<sup>12</sup>C method. Currently, the O<sub>2</sub> method gives a net global terrestrial biospheric CO<sub>2</sub> flux of -0.2±0.7 PgC/yr and -1.4±0.7 PgC/yr for the 1980s and the 1990s, respectively. Both the O<sub>2</sub> and <sup>13</sup>C/<sup>12</sup>C methods have complications and limitations that will be discussed.

To partition the global biospheric flux further to zonal or regional detail or to shorter time steps, atmospheric models are required to simulate the transport of tracer from source regions to individual stations where air is sampled. An ongoing collaborative project to compare atmospheric models has highlighted significant differences in transport characteristics, mainly owing to differences in how the boundary layer is modeled. Accordingly, a recent compilation of model calculations showed a wide range of estimates for the tropical biosphere, from a significant release of CO<sub>2</sub> to an uptake over recent decades; however, the calculations showed reasonable agreement on a significant northern biospheric sink.

Fluxes of biospheric CO<sub>2</sub> can be determined accurately at the global scale as well as at individual sites. An ingenious blend of observations and models will be required to bridge the gap between these two extreme spatial scales, and thereby gain an understanding sufficient to predict the influence of the terrestrial biosphere on variations in atmospheric CO<sub>2</sub>.

## B51C-11 1135h

Modeling inter-annual variability at  
baseline CO<sub>2</sub> stations: Contributions  
from sources and transportRoger J. Dargaville<sup>1</sup> (303 497 1732; rjd@ucar.edu)Scott C. Doney<sup>1</sup> (303 497 1639; doney@ucar.edu)<sup>1</sup>National Center for Atmospheric Research, PO BOX 3000, Boulder, CO 80307, United States

Both the surface source variability and variability in atmospheric transport impact the observations of atmospheric CO<sub>2</sub> at baseline monitoring stations. Previously it was assumed that the contribution due to transport inter-annual variability was minor. Using the off-line tracer transport model MATCH (Model of Atmospheric Transport and Chemistry) and dynamics from the NCAR CCM2 (Community Climate Model) and the NCEP (National Centers for Environmental Prediction) reanalysis we demonstrate that the contribution of transport variability can be significant and should be considered in interpretations of observed CO<sub>2</sub> variability. The CCM2 runs recycle a single year of winds while the NCEP runs use wind fields that exhibit realistic transport inter-annual variability. CO<sub>2</sub> sources are taken from transient simulations (i.e., with inter-annual variability) of the terrestrial carbon fluxes by TEM (Terrestrial Ecosystem Model) and the LPJ (Lund-Potsdam-Jena) models forced with climate data from Jones (1994) and Hulme (1992 & 1994). The two ecosystem models bracket the range of simulated behavior, with the TEM fluxes exhibiting much less year to year variability than LPJ, in part due to TEM taking into account nitrogen limitations while LPJ includes fire disturbance. A sensitivity experiment with the NCEP dynamics was also conducted with a repeated seasonal cycle of CO<sub>2</sub> fluxes to isolate the impact of transport variability explicitly. We show that the difference between the CCM2 and NCEP runs is primarily due to transport variability and that the inclusion of the year to year changes in circulation significantly improves the correlations of the simulated and observed deseasonalized concentration anomalies in both the TEM and LPJ cases. The inclusion of transport inter-annual variability also increases the magnitude of the variability in the simulated concentrations anomalies, shifting the standard deviations from TEM

and LPJ simulations closer to and in excess of the observed values, respectively. These experiments highlight the need to use realistic inter-annual forcing in model-data comparisons.

## B51C-12 1150h

Simulation of Interannual Variability in  
the Terrestrial Carbon CycleStarley L. Thompson<sup>1</sup> (925-423-9923;  
thompson59@llnl.gov)Bala Govindasamy<sup>1</sup> (925-423-0771; bala@llnl.gov)<sup>1</sup>Lawrence Livermore National Lab, 7000 East Ave. L-103, Livermore, CA 94550, United States

Recent observational and modeling studies have shown that the net flux of carbon from the global terrestrial ecosystem is subject to substantial interannual variability. We use an integrated atmospheric general circulation and biosphere dynamics model to investigate the nature and source of this variability in the terrestrial carbon cycle. The Community Climate Model 3 (CCM3) coupled to the Integrated Biosphere Simulator (IBIS 2) is used to perform a 16-member ensemble of AMIP-type present day simulations with observed sea surface temperatures (SSTs) for the period 1979-1992. Interannual global variations in terrestrial carbon uptake as simulated are of the proper magnitude and have good positive correlation with inferred uptake from observationally driven inverse modeling for the same time period. While our ensemble simulations do permit the extraction of a SST-driven signal, they also show that nearly 65% of interannual variability is driven by "internal" chaotic climate variability not related to variations in SST. This unforced interannual variability in carbon uptake appears to originate mainly from the unforced variability in Net Primary Productivity which in turn is driven by the chaotic variability in interannual precipitation and surface temperature.

B06. Water, Energy, and Carbon Cycles in Terrestrial Systems: Measuring and Modeling From Site to Region Sponsor: Geosciences

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Index terms: 0400 1851

## B52A MC: 122 Friday 1330h

Synthetic Analyses of Large-Scale  
Ecological Processes II

Presiding: G Hurtt, University of New Hampshire; J Foley, University of Wisconsin

## B52A-01 1330h

## The Synthesis Challenge

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Terrestrial ecosystems are heterogeneous across a wide range of spatial and temporal scales. This heterogeneity poses major challenges for observation, experimentation, modeling, and ultimately the synthetic understanding of important large-scale ecological processes. From leaf level measurements to plot scale experiments, from towers to forest inventories, from remote sensing to integrated atmospheric observations, approaches are needed for simultaneously interpreting such heterogeneous data in a self-consistent manner. In this talk, I will motivate and provide some perspectives on emerging synthetic approaches for large-scale ecosystem analysis.

## B52A-02 1345h INVITED

Synthesizing the Global Biogeochemical  
Cycle of BoronWilliam H Schlesinger<sup>1</sup> (919-613-8004;  
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