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1

Ahn, SoEun. 1997. Economic Analysis of the Potential Impact of Climate Change on Recreational Trout Fishing in the Southern Appalachians. *Ph.D. Thesis, North Carolina State University, 137 pages.*

This study focuses on economic analysis of the potential impacts of climate change on recreational trout fishing in the Southern Appalachian Mountain area of North Carolina. Significant decreases in trout habitat and/or populations are expected in the study area if water temperature increases due to global

warming. The main purpose of this study is to estimate the trout angler's welfare loss from the reductions of trout habitat and/or population in recreational trout fishing based on the climate change scenarios. Nested multinomial logit random utility models (RUMs) were used for the economic assessment and two nesting structures were examined -- the first with two decision levels and the second with three decision levels -- to describe an angler's choice behavior given a single occasion. The five scenarios used for estimating trout angler's welfare changes were 10, 20, 30, 40, and 50% reductions in both stream length and trout populations.

An angler's median compensating variation (CV) measures, the measure of an angler's monetary welfare loss, for each of the five scenarios from the two-level nested model were -\$1.36, -\$2.66, -\$3.92, -\$5.14, and -\$6.32 per trip in 1995 dollars. With the three-level nested model, median CV measures for each of the five scenarios were -\$0.35, -\$0.69, -\$1.02, -\$1.34, and -\$1.64.

Major Professor(s): de Steiguer, J. Edward
Department: Forestry
Principal Investigator(s): Abt, Robert C.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CLIMATE, ECONOMICS, FISH, MODEL

2

Arunachalam, Valli. 1996. Ultrafine Aerosol Particles: Long-Range Interactions, Aggregation Kinetics and Structure. *Ph.D. Dissertation, Texas A&M University, 131 pages.*

A theoretical and computational study of ultrafine aerosol particle aggregation including the long-range van der Waals interaction force is presented. Previously, studies of aggregation have not rigorously incorporated the effects of particle interactions. The significance of this work lies in the use of physically motivated interaction potentials in calculations of aggregation. In the first part of this study, a highly accurate approximation is developed whereby, for the first time, the van der Waals energy can be calculated for any geometry. In the aggregation process considered here, the geometry of interest is an irregular aggregate of adhering, spherical primary particles and an approaching primary particle (monomer). The effect of retardation of the long-range energy is also incorporated. In the second part of this study, the effect of these retarded, long-range van der Waals interactions, particle transport and ambient pressure and temperature on aggregate-monomer collision rate constants and aggregate structure are investigated by performing molecular dynamics simulation calculations. Glassy carbon is chosen as the prototype material for simulations. In general, the aggregates grown with the interaction potential tend to have relatively open structures, with few branches, while the aggregates grown without the potential tend to be more compact and branched. Further, the interaction potential results in enhancements in the collision rate

constants over the corresponding geometric rate constants. The effects are smaller in the transition regime than in the free molecular regime. Simulations performed with the non-retarded and the retarded interaction potential show that the percentage of relatively open aggregates, and the magnitude of the collision rate constants are greater in the latter case than in the former. An increase in temperature resulted in a collapse of aggregate structure and decrease in collision rate constants. The effects are more pronounced in the free molecular than in the transition regime. No significant difference was observed in the structure of the aggregates or in the aggregate-monomer collision rate constants as a result of changing the pressure of the simulations from 760 mm to 3040 mm.

Major Professor(s): Marlow, William H.
Department: Nuclear Engineering Department
Principal Investigator(s): Marlow, William H.
Program Area: Atmospheric Chemistry

KEYWORDS: AEROSOL, AGGREGATE

3

Bahrmann, Chad. 1997. The Influence of Air Mass History on Black Carbon Concentrations in the Southeastern US. *M.S. Thesis, North Carolina State University, 64 pages.*

Atmospheric black carbon concentrations in the southeastern US have been measured at a regionally representative site near Mt. Mitchell, NC (35° 44' 05" N, 82° 17' 15" W, 2038 m elevation), the highest peak in the eastern US, during a nine month period from June to October 1996 and March to June 1997. Black carbon concentrations are measured by an Aethalometer, which operates by measuring the attenuation of light through a sample. This attenuation is attributed to accumulated black carbon on the sample medium. All measured black carbon concentrations are reported in terms of air mass histories determined from back trajectory analysis using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HY-SPLIT) model. Air masses influencing the site have been classified as polluted, marine, and continental according to sulfate and nitrate emission inventories. The average BC mass concentrations for each sector are: 216.6 ~ 47.8 ng m⁻³ for polluted air masses, 65.6 ~ 23.5 ng m⁻³ for marine air masses, and 169.9 ~ 50.6 ng m⁻³ for continental air masses. A strong positive relationship between cloud condensation nuclei and

black carbon concentrations suggest at times the black carbon measured at the site may be internally mixed. The average black carbon concentration found in cloud water is 74.2 g of black carbon per kilogram of cloud water. Clear air black carbon to sulfate mass ratios ranged from 0.01 to 0.06 and will therefore, only slightly reduce the cooling effect caused by the direct forcing of sulfate aerosols.

Major Professor(s): Saxena, Vinod K.
Department: Marine, Earth and Atmospheric Sciences
Principal Investigator(s): Saxena, Vinod K.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: AEROSOL, CARBON, CLOUDS, CONDENSATION

4

Barnes, Diana H. 2000. Urban Pollution of Mitigated Greenhouse and Ozone-depleting Gases. *Ph.D. Thesis, Harvard University, 328 pages.*

The Montreal Protocol in 1987 and its subsequent London (1990) and Copenhagen (1992) Amendments mandated control measures on the production and consumption of ozone-depleting substances. The majority of the substances, including CFC-11, CFC-12, CFC-113, Halon-1211, CCl₄, and CH₃CCl₃, were scheduled for 100 percent reductions by 1 January 1996 in developed countries. Global background measurements taken in remote (far from the pollution sources) locations over the last decade have indeed indicated a deceleration in the atmospheric growth rates for many of the species and, for some of the shorter lived molecules, notably CH₃CCl₃, declining atmospheric concentrations are now being observed [list references of NOAA papers]. While these remotely-based measurements give insight to the health of the atmosphere at large, our ability to tally the spatial and temporal emissions of these chemicals on a regional basis during production, transport, and consumption may now be compromised, given that today such activities are subject to fines and may not be reported willingly. Atmospheric modelers, concerned about ozone depletion, are constrained to rely on either remote observations or county and state emission reports to the EPA, which in turn are based on factory inventories. To address this difficulty, this study provides an independent measure of emissions of ozone-depleting species for the years 1996 through 1998, well beyond the year in which they were fully

banned by the Montreal Protocol. The measurements were taken every 24 minutes at Harvard Forest, MA, downwind of the Northeast urban-industrial corridor, including the greater metropolitan region of New York City. Using the well-documented EPA CO emissions inventory and a combination of the Midgely and McCulloch PCE sales-based inventory and EPA/TRI PCE emissions inventory, we estimate the annual urban/industrial emissions of CFC-11, CFC-12, CFC-113, CH₃CCl₃, Halon-1211, CHCl₃, H₂, CH₄, and SF₆ all on a per capita basis for the New York City--Washington, D. C. corridor. We compare our results to those of inventories for the Northeastern, U.S., for the U.S. as a whole, for Europe, and for the world, where available.

Major Professor(s): Wofsy, Steven C.
Department: Earth & Planetary Sciences
Principal Investigator(s): McElroy, Michael B.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: AIR QUALITY, HALOGEN SPECIES, HALOGENATED HYDROCARBON, HYDROGEN, METHANE, MONTREAL PROTOCOL, URBAN ENVIRONMENT

5

Bauerle, William L. 1997. Diurnal Water Potential Gradients in Relation to Water Loss from Old Growth Douglas-Fir (*Pseudotsuga menziesii*) Trees. *M.S. Thesis, University of Washington, 67 pages.*

The use of a high rise canopy crane installed in an old growth Douglas-fir forest aided in the collection of xylem pressure potential and water loss measurements. Predawn and solar noon xylem pressure potential measurements were made along a 64.7 meter gradient of Douglas-fir canopy height. The measured gradient at predawn or under no flux conditions was about -0.01 MPa per meter of height. This value matches the theoretical hydrostatic gradient. Thermocouple psychrometry and porometry were used to confirm xylem pressure potential measurements made by the pressure chamber. The data in this study support the pressure chamber as a valid eco-physiological instrument to estimate water potential and describe water transport in plant material.

Major Professor(s): Hinckley, Thomas M.
Department: Forest Resources
Principal Investigator(s): Hinckley, Thomas M.

Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: FLUX, PRESSURE, SAP, STOMATE, TRANSPIRATION, VEGETATION, WATER

6

Bowling, David Randall. 1999. Stable isotope analysis of carbon dioxide exchange in a Tennessee hardwood forest. *Ph.D. Thesis, University of Colorado, 204 pages.*

Observations of the patterns of biosphere-atmosphere exchange of CO₂ and its isotopic forms, and of the diurnal and seasonal dynamics of these molecules have the potential to substantially increase our knowledge of the processes controlling carbon cycling in ecosystems. In this dissertation, new techniques have been developed and associated experiments conducted in a temperate deciduous forest in eastern Tennessee (Walker Branch Watershed) to elucidate the biological and physical processes controlling forest-atmosphere carbon dioxide exchange. Measurements of canopy-level fluxes of isoprene are described and compared to eddy covariance measurements. Excellent agreement was obtained between the two techniques, providing the first direct comparison between these two methods for a reactive compound. The relaxed eddy accumulation technique was modified to produce measurable atmospheric signals in isotopic composition of CO₂. Direct measurements of the fluxes of CO₂ and its component stable isotopes were made using relaxed eddy accumulation and standard eddy covariance combined with flask sampling. These data are the first flux measurements reported for these compounds over natural ecosystems. Mass balance equations are derived to use net isotopic flux measurements to partition net ecosystem exchange into its component fluxes, net photosynthesis and respiration.

Major Professor(s): Monson, Russell K.

Department: EPO Biology

Principal Investigator(s): Monson, Russell K.

Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ATMOSPHERE, CARBON DIOXIDE, FLUX, FOREST, PHOTOSYNTHESIS, RESPIRATION, TERRESTRIAL ENVIRONMENT

7

Bowman, Jean Ann. 1999. The Role of Continental Moisture Recycling in Climate Model Precipitation and Climate Change Impact Research. *Ph.D. Thesis, Texas A&M University, 72 pages.*

This research examines the effect of continental moisture recycling on climate model precipitation to determine the extent to which land surface hydrologic process approximations contribute to imprecise model precipitation simulations. The inability of climate models to accurately simulate regional precipitation patterns may be attributed to inaccuracies in (1) atmospheric moisture transport processes, and (2) moisture exchanges between the land surface and the atmosphere. It is difficult, however, to quantify the relative role each of these plays in the problem. Estimation of model moisture recycling is evaluated as a potential method of differentiating between the sources of model error. Two climate simulations are performed using the National Center for Atmospheric Research (NCAR) global atmospheric general circulation model (GCM) known as the Community Climate Model (version 2) (CCM2). Moisture recycling is also estimated using results from a reanalysis climate modeling project. Total model precipitation for four large continental regions is partitioned into contributions from moisture transported into the region and moisture recycled locally through evaporation. Moisture recycling is expressed as Pm/P , where Pm is locally-recycled moisture (from a specified land surface region) and P is total precipitation. The moisture recycling ratio, inward moisture flux, moisture divergence, precipitation and evaporation quantities are compared as monthly means to observations of those quantities for each of the four geographic regions, and to estimates of the quantities published by Brubaker et al. (1993). Monthly mean CCM2 precipitation from the non-BATS simulation is also compared to both sets of model results and to the Brubaker et al. (1993) results. Differences in monthly mean precipitation originating from all four of the sources (three models and one set of published results) are clarified by comparing the annual cycles and through an analysis of variance. To further evaluate the extent to which the moisture recycling process describes model precipitation error, model precipitation is adjusted using the difference between the Brubaker et al. (1993) recycling and computed model recycling. This is done for each of the four geographic regions of interest, and the resulting scaled precipitation series are again compared to observed for each region respectively.

Major Professor(s): North, Gerald R.

Department: Geography
Principal Investigator(s): Wurbs, Ralph A.
Program Area: National Institute for Global
Environmental Change (NIGEC)

KEYWORDS: CLIMATE, HYDROLOGY, MODEL,
MOISTURE, PRECIPITATION

8

Bremer, Dale. 1998. Effect of Burning and Grazing on Carbon and Energy Fluxes in a Tallgrass Prairie. *Ph.D. Dissertation, Kansas State University, 129 pages.*

Burning and grazing are the two most common forms of land management on grasslands and may influence ecosystem energy, carbon (C), and water budgets. Increasing concentrations of atmospheric CO₂ may also affect these factors. The objectives of this study were to measure the effects on a tallgrass prairie of: 1) grazing on soil-surface CO₂ flux (Fs); 2) burning on energy fluxes and evapotranspiration (ET); and 3) elevated CO₂ on Fs, soil water content, and microbial C under severe drought. Comparative measurements of Fs were collected from grazed and ungrazed pastures, and from plots hand-clipped to simulate grazing. Annually, Fs ranged from 8.8 x 10⁻³ mg m⁻² s⁻¹ during the winter to 0.51 mg m⁻² s⁻¹ during the summer, following the patterns of soil temperature and canopy phenology. Clipping typically reduced Fs by 21 to 49% within 2 days of defoliation. Cumulative annual Fs was 4.94 kg m⁻² in unclipped plots and 4.08 kg m⁻² in clipped plots; thus, clipping reduced annual Fs by 17.5%. Daily Fs in grazed pastures was 20 to 37% less than in ungrazed pastures. The surface energy balance and ET were measured during the growing season on burned (B) and unburned (UB) watersheds. During the first 6 weeks after the burn, lower albedo on the B site raised available energy (net radiation minus soil heat flux) by 8.6% compared with the UB site. The absence of dead biomass on the B site induced a three-fold increase in surface conductance to water vapor and consequently, average ET was higher on the B (2.97 mm d⁻¹) than on the UB site (1.40 mm d⁻¹). Differences in albedo and available energy between sites diminished by June 1, but ET remained higher on the B site because of its greater leaf area index. By July 1, the effects of the burn on ET were negligible. Cumulative estimates of seasonal ET were 503 mm on the B site and 367 mm on the UB site; thus, burning increased seasonal ET by 23.4%. Measurements of Fs, soil water content, and microbial C were collected from CO₂-enriched and ambient CO₂ open-top chambers during an induced

drought. The average soil water content in the 1.5 m profile was significantly higher under elevated CO₂, but extremely dry soils in the upper part of the profile kept Fs low in both treatments. Nevertheless, Fs was significantly higher under elevated CO₂. However, no differences in microbial C between treatments were apparent. Results indicate that land management factors such as grazing and burning have strong impacts on energy, C, and water budgets in grasslands. Increased atmospheric CO₂ may also affect C dynamics in prairies during severe drought.

Major Professor(s): Ham, Jay
Department: Agronomy
Principal Investigator(s): Ham, Jay
Program Area: National Institute for Global
Environmental Change (NIGEC)

KEYWORDS: CARBON, CARBON DIOXIDE,
COMBUSTION, ENERGY FLUX,
EVAPOTRANSPIRATION, FERTILIZATION,
GRASSLAND, GRAZING, MICROBE, RADIATIVE
PROCESS, RESPIRATION, SOIL, STRESS, WATER,
WATER USE

9

Brogan, Sean. 1997. Expert Estimates of Climate Change Impacts On Southern Appalachian Coldwater Fisheries. *M.N.R. Thesis, North Carolina State University, 95 pages.*

Regional climate warming may increase ground and streamwater temperatures resulting in the loss of fish habitat. This study summarized the opinions of thirty-eight coldwater fisheries experts regarding the impacts of climate change on Southern Appalachian brook trout (*Salvelinus fontinalis*), brown trout (*Salmo trutta*) and rainbow trout (*Oncorhynchus mykiss*). A 4.6 degree C and 25% reduction in summer water levels represented future climate change conditions. Median responses by experts indicated stream and groundwater temperature increases of 3.0 degrees C and 1.0 degree C, respectively; a 5% rise in trout metabolic rates; a 3% decline in dissolved oxygen content; a 5% decrease in brown trout habitat and a 10% reduction in brook and rainbow trout habitat.

Major Professor(s): de Steiguer, J. Edward
Department: Forestry
Principal Investigator(s): Abt, Robert C.
Program Area: National Institute for Global
Environmental Change (NIGEC)

KEYWORDS: CLIMATE, FISH

10

Brondizio, Eduardo. 1996. Forest Farmers: Human and Landscape Ecology of Caboclo Populations in the Amazon Estuary. *Ph.D. Dissertation, Indiana University, 481 pages.*

This is a study of agricultural and agroforestry intensification in the Amazon estuary and its socio-economic and environmental implications. Remote sensing, vegetation ecology, and socio-economic assessment are integrated in a multiscale fashion, and different land use systems are compared with special emphasis to ACAI agroforestry systems (*Euterpe oleracea*). Agroforestry intensification in the floodplains carried out by Caboclo populations presents an economically and ecologically viable alternative for food production in the region that provides reliable incomes for local populations without increase in deforestation rates.

Major Professor(s): Moran, Emilio
Department: School of Public and Environmental Affairs
Principal Investigator(s): Moran, Emilio
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: AGRICULTURE, ESTUARY, FOREST, LAND USE, TROPICS

11

Brown, Kimberly J. 2000. Canopy Architecture of Clonal Hybrid *Populus*: Implications for Light Reflectance, Interception, and Physiology. *Ph.D. Thesis, University of Washington, 160 pages.*

Various-sized monoculture plantation blocks of *P. deltoides* x *P. nigra* (DN) and *P. trichocarpa* x *P. deltoides* (TD) hybrid poplars were distinguishable in an AVIRIS image of a fiber farm in eastern Washington State. Presuming an operational plantation would use clones of equal productivity, three hypotheses were posited and tested: (1) the two *Populus* hybrids would have equal above-ground productivities; (2) clonal differences in canopy architecture would be linked to differences in canopy light dynamics; and (3) for equal clone productivity, differences in clonal hybrid leaf morphology and physiology must exist to compensate for differences in canopy architecture and

light interception. Repeated destructive harvests and canopy architectural and leaf physiological measurements were made from 1996 to 1998. Mean whole-tree aboveground biomasses and leaf areas were similar between the two clones (DN=57.97 ± 9.89 s.e., TD= 54.77 ± 16.62 kg, DN=5.9 ± 1.5, TD= 4.6 ± 2.1 m² leaf area tree⁻¹). Significant clonal canopy architectural differences were: the DN clone had more branches, narrower branching angles, a deeper live crown, a more vertical upper canopy leaf angle distribution, and a lesser light extinction coefficient ($k = 0.33$); the TD clone had fewer, more open branches, a shorter live crown, a more horizontal upper canopy leaf angle distribution, and a greater k (0.46). For DN and TD, leaf mass per unit area, chlorophyll, leaf nitrogen, leaf thickness, and cell size were influenced by relative canopy position but did not differ interclonally. Similarly, both clones shared similar leaf photosynthetic responses to controlled manipulations of light or CO₂ conditions within a relative canopy position. A multi-layered canopy model with equal leaf photosynthetic parameters but different canopy architectural and light interception parameters was used to simulate whole-tree maximum potential net photosynthesis (MPNP) for DN and TD (after Bond et al. 1999). In the model, the interactions of vertical leaf area distribution (VLAD), k , and leaf angle distributions in each clone resulted in equally illuminated leaf area and similar MPNP for the two clones. Clonal differences in leaf angle most strongly influenced MPNP by altering whole-canopy leaf area illumination.

Major Professor(s): Hinckley, Thomas M.
Department: Ecosystem Sciences
Principal Investigator(s): Hinckley, Thomas M.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: LEAF AREA INDEX (LAI), MORPHOLOGY, PHOTOSYNTHESIS, PHYSIOLOGY, STOMATE, TRANSPIRATION, TREE

12

Burba, Georgiy G. 1996. Energy Fluxes in a Mid-Latitude Prairie Wetland Ecosystem. *M.S. Thesis, University of Nebraska at Lincoln, 95 pages.*

Components of the energy budget (net radiation, energy storage, and sensible and latent heat fluxes) were measured in three communities (*Phragmites australis*, *Scirpus acutus*, and open water) in a marsh located in

north central Nebraska during the growing season of 1994. The Bowen ratio-energy balance method was used to calculate sensible and latent heat fluxes. During daytime, the energy storage term (G) consumed 45-60% of the net radiation (R_n) in open water, and 20-30% in the two emergent communities (*Phragmites* and *Scirpus*). During nighttime, G was a significant source of energy in all three communities and, therefore, the daily (24 hours) averaged values of G were small. Evapotranspiration (ET) was a major consumer of the incoming solar energy in *Phragmites* and *Scirpus*. During early and peak growth, the daily ET in the two emergent communities ranged between 2.5 and 6.5 mm d^{-1} utilizing around 80-90% of R_n . As compared to the ET from *Phragmites* and *Scirpus*, the evaporation (E) from open water was about 25% smaller during daytime, and 2-3 times larger during night. For the entire measurement period, the daily integrated E in open water was 4.1 mm d^{-1} , and the daily integrated ET was 3.8 mm d^{-1} in *Phragmites* and 3.5 mm d^{-1} in *Scirpus*. Before senescence, the daily ET in *Phragmites* and *Scirpus* was between 75 and 100% of the potential rates (ET_p). During senescence, the percentage was 10-75%. In open water, the daily E was 60-100% of the potential rate throughout the measurement period. ET in *Phragmites* was partitioned into transpiration (E_v) and evaporation (E_s) using a dual-source modification of the Penman-Monteith equation. During the early and peak growth stage, E_v contributed 40-62% of the total ET (E_v ranged from 1.7 to 3.5 mm d^{-1} and E_s ranged from 1.0 to 3.2 mm d^{-1}). During senescence, E_v decreased, and by the end of the season, the E_v/ET ratio reached negligible values. The daytime variation of E_s in *Phragmites* (as well as that of E in open water) did not follow R_n . The variation was primarily controlled by thermal stability and air dryness.

Major Professor(s): Verma, Shashi B.
Department: Agricultural Meteorology
Principal Investigator(s): Verma, Shashi B.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ENERGY FLUX, EVAPORATION, FLUX, HEAT, PRAIRIE, TRANSPIRATION, VEGETATION, WETLAND

13

Chen, Wanchun. 2000. Assessment of Land Surface Energy Budgets in GCIP CART/ARM Region. *M.S. Thesis, University of Maryland, 21 pages.*

The surface energy budgets of the operational Eta and GEM models were evaluated with in-situ observations and satellite products. Time series output from the Eta and the GEM models were evaluated by comparison to measured values at CART/ARM region for winter 1998/1999. Surface energy budget components, soil moisture and cloud indicators were examined. The correlation between downward short wave radiation and cloud cover fraction was also computed. It was found that for ETA model, the bias in latent heat flux and Bowen ratio are consistent with the bias in soil moisture: the positive bias in soil moisture results in larger than observed latent heat flux and, consequently, smaller Bowen ratio. The GEM model has a remarkable representation of the downward short wave radiation and the net radiation at the surface, but surface heat fluxes, particularly the ground heat flux, reveal biases.

Major Professor(s): Stenchikov, Georgiy L.
Department: Department of Meteorology
Principal Investigator(s): Stenchikov, Georgiy L.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: BOWEN RATIO, ETA MODEL, GEM MODEL, LATENT HEAT, SENSIBLE HEAT, SOIL MOISTURE

14

Chung, Hong-Fu. 1996. Measuring Economic Welfare Effects of Supply Shifts in the Southern Softwood Stumpage Market: With Application to Climate Change Impact Analysis in the Forest Sector. *Ph.D. Dissertation, North Carolina State University, 125 pages.*

Price shifts in a given market could cause prices in other markets to shift. Such multi-market price effects could make the measurement of economic welfare difficult. This is because changes in welfare - as measured in changes in producer and consumer surpluses under compensated market schedules - may not be confined to the original market; instead, they may cross over to horizontally and vertically integrated markets upstream and downstream from the original market. A test was made to determine whether such crossover price effects were significant in the Southern softwood timber market. To perform such a test, a two separate market models were estimated from the same cross sectional data set of timber harvests and standing live volume. One timber market model was partial

equilibrium (PE) in nature while the other was general equilibrium (GE). The PE model assumes that prices in adjacent markets are held fixed; in contrast, the GE model drops non-timber prices from the specification. The resulting models showed incongruous results for the market for sawtimber, but a well behaved pulpwood market. A statistical test of the slopes of the demand curves of the two models on the pulpwood market failed to reject the null hypothesis that they were equivalent. Consequently, this study is not able to provide strong evidence that price effects and therefore welfare effects in the Southern softwood pulpwood market transfer over to other markets in the economy. Nevertheless, the study did find that the GE demand curve for timber was more own-price inelastic than the PE demand curve. The result conforms to what microeconomic theory would predict. Finally, a case application was made applying both PE and GE market models to scenarios of global climate change. Differences in welfare impacts as large as two fold were found. It helps to illustrate the potential range of welfare measures that could occur if a PE modeling framework was used instead of a GE modeling framework.

Major Professor(s): de Steiguer, J. Edward
Department: Forestry
Principal Investigator(s): Abt, Robert C.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ECONOMICS, FOREST, MODEL

15

Crocker, Jennifer. 1997. Ecophysiological Significance of Nonhydraulic Root-to-shoot Signaling in Control of Stomatal Behavior During Soil Drying. *M.S. Thesis, University of Tennessee, 82 pages.*

The objectives of this study were to: (1) characterize stomatal response of six deciduous tree species to nonhydraulic root-sourced signals of soil drying, and (2) test whether species sensitivity to nonhydraulic signaling is allied with their drought avoidance and tolerance profiles. Saplings were grown with roots divided between two pots. Three treatments were compared: half of the root system watered and half droughted (WD), half of the root system watered and half severed (WS), both halves watered (WW). Drying about half of the root system caused nonhydraulic declines in stomatal conductance (g_s) in all species, with g_s of WD plants reduced to from 40% to 60% of WS controls. Declines in g_s were closely related to

declining soil matric potential between -0.01 and -0.10 MPa. Soil matric potential required to cause declines in g_s of WD plants to 80% of WS controls varied from a high of -0.013 to a low of -0.044 MPa. Stomatal inhibition varied somewhat with leaf age in half of the species. Leaf osmotic potentials during soil drying were mostly similar among treatments. Although stomatal sensitivity to the nonhydraulic, root-sourced signal (characterized as decline in g_s per unit decline in soil matric potential) was not closely correlated with previously identified lethal leaf water potentials or capacity for osmotic adjustment, species having the highest stomatal sensitivity also had the least dehydration tolerance. This suggests that stomatal sensitivity to nonhydraulic root signals may be mechanistically linked to a limited extent with other characteristics defining relative species drought tolerance.

Major Professor(s): Augé, Robert M.
Department: Institute of Agriculture
Principal Investigator(s): Augé, Robert M.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ROOT, SOIL, STOMATE, STRESS, VEGETATION, WATER

16

DeLuca, Cecilia. 1996. Means and Variability of Some Aspects of the Hydrological Cycle. *M.S. Thesis, Massachusetts Institute of Technology, 114 pages.*

Means and interannual variability of moisture flux divergence and precipitable water are calculated for the years 1965 through 1989 from a GFDL global atmospheric dataset. An empirical orthogonal function (EOF) analysis assesses portions of the variability due to long-term trends, the effect of the El Nino Southern Oscillation, and other factors. Apparent long term trends are discussed in light of the deficiencies- of the dataset, other studies, and statistical significance tests. Little conclusive evidence that the trends reflect physical phenomena is found, with a convergent trend in northern high-latitudes a possible exception. In the latter part of the thesis, the monthly-mean moisture flux divergence is equated with runoff and is used to drive a GISS river model, which routes moisture collected on land to oceans. Based on the results of the model and divergence data over land and ocean regions, the annual mean and interannual variability of the freshwater flux into the Atlantic is computed for 4°

latitude strips and for the northern, mid- and southern Atlantic. For the northern Atlantic, mean fluxes are in good agreement with models and observational studies. For the mid- and southern Atlantic there are inconsistencies between this and other studies that reflect the scarcity of radiosonde data over tropical oceans and the southern hemisphere. A possible application of the computed fluxes and their variances is the validation and forcing of atmosphere, ocean or coupled models. This may be feasible with the results obtained for high northern latitudes, but is not likely to yield meaningful results south of about 40°N. Included in an appendix is a catalogue of graphical statistics, with seasonal and annual means, interannual variability (including EOF analyses), and zonal means of a number of hydrological fields, including moisture fluxes.

Major Professor(s): Peter Stone
Department: Earth, Atmospheric and Planetary Sciences
Principal Investigator(s): Rosen, Richard
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: FLUX, HYDROLOGY, MODEL, MOISTURE, PRECIPITATION, RIVER, TEMPORAL DISTRIBUTION, WATER

17

Dyhrman, Sonya T. 1999. Cellular Markers of Phosphate Stress in Phytoplankton. *Ph.D. Dissertation, University of California San Diego, 156 pages.*

Primary production in the world ocean sustains marine organisms and modulates global climate. As a result, the factors that regulate phytoplankton production are a source of extensive investigation. Much attention focuses on the role of nutrients, such as nitrogen and phosphorus, in the regulation of phytoplankton growth and bloom dynamics. However, such studies have been hampered by the difficulties involved in assessing single-cell phytoplankton physiology *in situ*. This research discusses the development of two *in situ* assays for phosphate stress in the dinoflagellate *Prorocentrum minimum*. This work also elucidates aspects of phosphate nutrition in this species and the coccolithophoris *Emiliania huxleyi*. For both organisms cell-surface proteins regulated by phosphate were characterized in laboratory cultures. The induction and repression of these proteins in response to phosphate supply were studied and compared with alkaline

phosphatase activity which is a commonly used marker of phosphate stress. In *P. minimum* one phosphate regulated protein was purified and identified as an alkaline phosphatase. The phosphate regulated proteins of *E. huxleyi* were partially purified, consistently associating with each other as well as with alkaline phosphatase activity. One of these proteins appears to be a phosphatase with an affinity for 5' nucleotides. Antibody probes were generated to the purified alkaline phosphatase in *P. minimum*. The antibody probes were tested for specificity to the target protein and for cross reactivity with other species of phytoplankton. An immunofluorescence assay using these antibody probes distinguished phosphate-stressed from phosphate-replete cells in culture and in a field sample. In *P. minimum* an additional assay for phosphate stress was developed using the fluorescent alkaline phosphatase substrate ELF-97. The phytoplankton population in Narragansett Bay, Rhode Island was sampled in the summer of 1998 and tested for phosphate stress using this assay. Cell-specific, *P. minimum* alkaline phosphatase activity was detected in the field samples. This study demonstrates the importance of phosphate in aspects of phytoplankton physiological ecology, particularly in this important estuary. It also confirms that the tools developed here may be used successfully in future studies of cell-specific phytoplankton physiological ecology.

Major Professor(s): Palenik, Brian P.
Department: Scripps Institution of Oceanography
Principal Investigator(s): Palenik, Brian P.
Program Area: Coastal Margins

KEYWORDS: COMMUNITY DYNAMICS, GROWTH AND DEVELOPMENT, NUTRIENT, PHOSPHATE, PLANKTON, STRESS

18

Foster, Sara. 1997. Decomposition of *Populus tremuloides* Leaves Grown Under Elevated Atmospheric Carbon Dioxide. *M.S. Thesis, University of Illinois at Chicago, 16 pages.*

I determined the C:N ratio of *Populus tremuloides* leaves grown under ambient and elevated CO₂, and the decomposition rates of the leaves under the conditions in which they had been grown. The N concentration of senescent leaves when they were put into litter bags was significantly affected by soil N and CO₂ treatments, but these differences in leaf "quality" did not affect decomposition rate. Leaf nitrogen concentration was

26% higher in leaves from trees in high N compared with low N soil ($p < 0.0005$, 3-way ANOVA), and 38% higher in leaves grown under ambient compared with elevated CO_2 ($p < 0.0001$, 3-way ANOVA). Soil N and CO_2 affected leaf N independently; there was no interaction effect. After 233 days, there were no treatment effects on mass loss rates of the leaves. Further, when the leaves were moistened and CO_2 production measured, there were no treatment differences. In summary, although the C:N ratio of *Populus tremuloides* leaves grown under elevated CO_2 was higher than that of control leaves grown under ambient conditions, the difference did not affect decomposition rate.

Major Professor(s): Lussenhop, John
Department: Biological Sciences
Principal Investigator(s): Teeri, James
Program Area: National Institute for Global
Environmental Change (NIGEC)

KEYWORDS: CARBON CYCLE, CARBON DIOXIDE,
DECOMPOSITION, FERTILIZATION, LEAF,
NITROGEN CYCLE, PHOTOSYNTHESIS,
RESPIRATION, SOIL

19

Fraser, Rolland. 1996. Multiscale (Spatial, Spectral, Temporal) Remote Sensing of Biogeochemical Conditions in Nebraska Sand Hills Lakes. *Ph.D. Dissertation, University of Nebraska at Lincoln, 250 pages.*

This dissertation applied remote sensing to several questions regarding lake water quality in the Nebraska Sand Hills. In Chapter 2, baselines of reflectivities were defined, from May to October, 1972 through 1986, as measured by the Landsat Multispectral Scanner, for 130 lakes in Garden and Sheridan counties, Nebraska. This yielded multispectral signatures and records of variation for the individual lakes. Chapters 3 and 4 addressed the basic problem of associating lake reflectivities with water quality parameters specific to Sand Hills lakes, using: a) 252 bands of hyperspectral reflectance data collected with a spectroradiometer from a helicopter, b) 7 bands of multispectral reflectance data collected by the Landsat Thematic Mapper, and c) water quality conditions of turbidity, algal chlorophyll-a and alkalinity. Results from both chapters yielded significant correlations of turbidity and chlorophyll-a with the spectral information. A record of hyperspectral reflectance from 32 lakes was established.

Chapter 5 was a cursory study on the spatial variability expressed by waterscape (landscape ecology analog) metrics within and among lakes, using reflectance classes as surrogates to aquatic habitats. Results showed that spatial metrics vary among lake spectral classes. Chapter 6 provided estimates of albedo, from hyperspectral reflectance data among lakes, and then used the results to examine the variability in lake radiation budgets. There were shifts in relative dominance between reflected shortwave and longwave components, which may be important in assessing lake impacts on local and regional climate or biological production. Each of these studies presented either new approaches to the study of water resources with remote sensing, or new and useful information about the many lakes in Nebraska's Sand Hills. Both aspects should prove useful in regional monitoring or comparisons with other regions of the world. Overall, the results provided evidence that remote sensing is a useful tool for studying water quality, and a developing science with new basic questions to be addressed.

Major Professor(s): Rundquist, Donald C.
Department: Geography
Principal Investigator(s): Rundquist, Donald C.
Program Area: National Institute for Global
Environmental Change (NIGEC)

KEYWORDS: PRAIRIE, RADIATIVE PROCESS,
REFLECTANCE, REMOTE SENSING, SPATIAL
DISTRIBUTION, WATER QUALITY

20

Friedman, Karen. 1997. Global Atmospheric Water Vapor Flux Climatology in the NCEP/NCAR Reanalysis and the Oort Data Set. *M.S. Thesis, Massachusetts Institute of Technology, 122 pages.*

The integrated water vapor flux is calculated for the National Centers for Environmental Prediction/ National Center for Atmospheric Research (NCEP/NCAR) reanalysis and the Oort objective analysis data sets with the purpose of intercomparison. The period of study is 1979 to 1995 for the NCEP/NCAR data and 1964 to 1989 for the Oort. Such lengthy time-series allow the estimation of interannual variability in the atmospheric branch of the hydrologic cycle. Global fields and zonal averages are displayed for the annual, December/January/February, and June/July/August averages. As part of the analysis, the data sets are each separated into years with and without an El Niño occurrence. The difference and divergence

are calculated to investigate if the data sets can resolve the anomalies known to exist during El Niño Southern Oscillation (ENSO). Power spectra analysis is also performed to look for events within certain frequency ranges. Both data sets appear to resolve the global water vapor flux and ENSO conditions reasonably, but the Oort data does not perform as well possibly due to regions with inherently poor data.

Major Professor(s): Dara Entekhabi
Department: Civil and Environmental Engineering
Principal Investigator(s): Rosen, Richard
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: EL NIÑO - SOUTHERN OSCILLATION (ENSO), FLUX, MOISTURE, TEMPORAL DISTRIBUTION, WATER VAPOR

21

Gray, Sean. 1998. Diagnosis of energy divergence in the GEOS-1 Reanalysis. *M.S. Thesis, University of Maryland, 16 pages.*

In single column modeling, boundary conditions must be specified to reproduce the climate. For our modeling efforts, we attempt to impose large-scale advective transport of latent and sensible heat, derived from data assimilation, as the horizontal boundary condition to our radiative-convective model. The computation of the divergence of advective fluxes is not a simple numerical procedure, because high levels of accuracy are needed. Here the advective fluxes for summer (averaged for 1988-1995) from the NASA GEOS-1 reanalysis is presented. The boundary conditions were calculated from the divergence of latent and sensible energy flux. The integrated effect of this flux was tested against the observed column energy convergence.

Major Professor(s): Stenchikov, Georgiy
Department: Department of Meteorology
Principal Investigator(s): Stenchikov, Giorgiy L.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CIRCULATION, CLIMATE, FLUX, HEAT, MODEL, RADIATIVE PROCESS

22

Green, Mark A. 1996. The Biogeochemical Mechanisms Driving Calcite and Aragonite Saturation

States in Long Island Sound Sediments: The Effects on Juvenile Bivalves, Benthic Foraminifera, and Carbonate Debris Preservation. *Ph.D Dissertation, State University of New York at Stony Brook, 257 pages.*

Few studies have considered dissolution of calcium carbonate in nearshore temperate, mud deposits where sediments are seldom more than 1-3% CaCO₃ by weight. However, knowledge of the processes that control CaCO₃ dissolution-preservation in all types of depositional environments are essential to fully understand the global CaCO₃ cycle. The purpose of this study was to better constrain the role of nearshore-temperate regions in the cycling of biogenic calcium carbonate by studying the seasonal patterns of CaCO₃ build-up and dissolution in Long Island Sound sediments. Pore water saturation state with respect to calcite and aragonite minerals in Long Island Sound sediments fluctuate from saturated and near saturated conditions during late fall, to undersaturated during winter, before slowly changing to supersaturated conditions during late spring. Higher ΣCO₂ production rates during warmer periods cause the CO₃²⁻ concentration to become supersaturated for both calcite and aragonite. ΣCO₂ production is controlled by both temperature and substrate availability so that benthic deposition of organic matter produced during the spring bloom accelerates the seasonal progression of pore waters to supersaturation. Undersaturation occurs during winter time when lower rates of ΣCO₂ production and oxidation of reduced minerals such as FeS lower CO₃²⁻ below saturation. Large benthic losses of Ca²⁺, Mg²⁺, Sr²⁺, and F⁻ occur when sediments are undersaturated with respect to carbonate minerals over a period of ~160 days. The prorated annual average flux range of -0.53 to -3.3 mmol Ca²⁺ m⁻² d⁻¹ (-2.0 ± 1.02 mmol Ca²⁺ m⁻² d⁻¹) is comparable to or greater than fluxes of Ca²⁺ documented from other nearshore carbonate regions as well as the deep sea, where little if any temporal variability in pore water saturation state occurs. Mass fluxes of Ca²⁺ from this study imply that between ~31.0 g CaCO₃ m⁻² dissolves during winter in LIS sediments. This translates to a Sound-wide loss during winter of ~5.6 x 10¹⁰ g CaCO₃. Rapid, significant declines in the total foraminifera assemblage of *Elphidium clavatum* and *Buccella frigida*, and the abundance of bivalves *Tellina agilis*, and perhaps to some extent *Nucula annulata*, correlate with the winter-time period of calcite/aragonite mineral undersaturation. Declines in the density of individuals can be explained by dissolution of the carbonate tests. Dissolution of some calcareous organisms during winter in LIS suggests one mechanism by which

systematic biases exist in the taxonomic and age class composition of the fossil record. What is ultimately preserved as a fossil may not actually represent all ecological groups that existed at the time of burial or reflect their actual abundances while living and/or shortly after death. A laboratory experiment showed that calcite undersaturation resulted in dissolution of previously discarded tests of the foraminifera *E. clavatum* and *B. frigida*, and also increased mortality of live individuals approximately 3 times relative to controls. SEM observations of foraminifera support the notion that dissolution was greater in experimental-undersaturated chambers relative to control-saturated chambers. No significant difference was seen between treatments for the bivalves *T. agilis* or *N. annulata*. However, dissolution-induced mortality in meiofauna other than foraminifera, such as juvenile bivalves, should not be discounted and deserves future attention.

Major Professor(s): Aller, Robert C., and Josephine Aller
Department: Coastal Oceanography
Principal Investigator(s): Aller, Robert C., Josephine Aller, Cindy Lee, and J. Kirk Cochran
Program Area: Marine Transport

KEYWORDS: CARBON CYCLE, COASTAL ENVIRONMENT, OCEAN, SEDIMENT, TEMPORAL DISTRIBUTION

23

Gu, Lianhong. 1998. Modeling Biophysical Exchanges and Micro-Meteorology in Soil-Vegetation-Atmosphere Continuums: Results from a Two-Story Boreal Aspen Forest. *Ph.D. Thesis, University of Virginia, 265 pages.*

While the description of vertical differentiation in the light environment has become a routine part of plant canopy process modeling, air temperature, water vapor partial pressure and CO₂ concentration have been often assumed to be constant over the canopy depth. Yet these variables exhibit vertical variations in most plant canopies. Since plant physiological activities are sensitive to temperature, water vapor partial pressure and CO₂ concentration, these often coupled gradients could have important impact on energy and mass exchanges between vegetation and the atmosphere. In this study, a multi-layer canopy process model for the exchanges of radiative energy, sensible heat, water vapor and CO₂ between vegetation and the atmosphere is developed. The model is designed to be applied to both one-story and two-story canopies. It first predicts

profiles of temperature, water vapor and CO₂ partial pressures in plant canopies. Then from these predicted profiles, exchanges of sensible heat, water vapor and CO₂ in each layer of the canopy are computed. Finally, canopy level fluxes are obtained by integrating these exchanges over the canopy. In the multi-layer model developed, short-wave radiative transfer within plant canopies is described by a modified two-stream model which can address the problem of canopy clumpiness. A longwave radiative transfer matrix (LRTM) technique is developed to model longwave radiative transfer in plant canopies. The revised localized near-field (LNF) theory is used to describe sensible heat, water vapor and CO₂ transfers within and just above the canopy. Stomatal conductance is computed by the Ball-Berry-Leuning model. Photosynthesis is described by a biochemical model. Soil moisture and temperature are modeled by the force-restore method. Soil respiration is described by an empirical temperature function. Stem respiration is modeled from temperature and sapwood taper in the canopy. Sapwood taper is estimated based on the pipe-model theory. Because of the complex relationships among different biophysical processes, some variables, such as leaf temperature, stomatal conductance for water vapor and internal CO₂ partial pressure, can not be expressed explicitly and independently. These variables are solved through a system of nonlinear equations which has $3m+5$ independent equations where m is the total number of foliage layers in the canopy. The numerical solution of this system by the Broyden's method is the core of the program of the model. A random fluctuation technique is developed to overcome the possible failure in the convergence of the iteration process and has been proved to be effective in the application. The model was tested comprehensively against measurements from a two-story boreal aspen forest in the southern study area of the boreal ecosystem-atmosphere study (BOREAS) project. The tests included diurnal cycles of canopy net radiation, sensible heat flux, water vapor flux, CO₂ flux and friction velocity, and profiles of air temperature, water vapor partial pressure and CO₂ concentration and their diurnal cycles. After being fully tested, the model was used to decompose fluxes of sensible heat, water vapor and carbon dioxide into contributions from ecosystem elements. Major conclusions obtained in this dissertation study can be summarized as follows:

- The model can make accurate predictions for fluxes of radiative energy, sensible heat, water vapor and CO₂ over this two-story forest, and profiles and diurnal patterns of air temperature, water vapor partial pressure and CO₂ concentration within and just above the canopy.
- Energy and mass exchanges in this boreal forest was

largely controlled by the abovestory even through its LAI was smaller than that of the understory. However, to model energy and mass exchanges, it is not sufficient to consider leaves only, and contributions from other elements of the ecosystem can not be neglected in general. In particular, respiration of stems and soil is a significant part of the carbon budget for this forest and must be included in the study of ecosystem productivity.

-- Ecosystem elements can have significantly different roles in determining canopy sensible heat fluxes than in determining canopy evapotranspiration or CO₂ assimilation. For example, the understory had a much bigger role in contributing to the fluxes of H₂O and CO₂ than in contributing to the sensible heat flux. In addition, their roles may change from nighttime to daytime.

-- The results showed that scalar transfers in this boreal forest can be described by the revised localized near-field theory, and problems of soil-vegetation-atmosphere transfers can be solved through a system of non-linear equations.

Major Professor(s): Shugart, Herman H. Jr.
Department: Environmental Sciences
Principal Investigator(s): Emanuel, William R.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: BOREAL REGION, FOREST, MODEL, RADIATIVE PROCESS, TERRESTRIAL ENVIRONMENT

24

Heffernan, Lisa. 1996. Measuring the Effects of Increased Levels of Carbon Dioxide on Soil Bacteria in a Mediterranean Type Ecosystem. *M.S. Thesis, San Diego State University, 51 pages.*

The levels of carbon dioxide have steadily increased over the past 200 years due to the clearing of land, use of fossil fuels, and tillage of soil. There are a number of different studies being conducted on both above-ground fauna and below-ground microbial life. Since there is a diversity of organisms in the soil it is often difficult to identify certain groups of organisms. For instance, methods for identifying nitrogen-fixing bacteria are variable, time consuming, and sometimes unreliable. With advances in molecular biology, more accurate methods in identification can be designed. This study addressed the question of how increased levels of CO₂ affect bacterial population numbers. CO₂-controlled, long-term greenhouse system (CO₂LT) and Free-Air CO₂ Enrichment (FACE) were used to simulate levels

of CO₂ from 250 ppm to 550 ppm and the response of this change in CO₂ on bacteria was measured during the first growing season. There were no significant changes in total bacterial numbers during the first growing season. At six months the dominant bacteria were also identified. The dominant bacteria at all CO₂ levels were identified as *Bacillus* species and potential nitrogen-fixing bacteria were identified from the lower concentration chambers. Finally, progress was made towards a molecular method to identify nitrogen-fixing bacteria.

Major Professor(s): Allen, Michael
Department: Biology
Principal Investigator(s): Oechel, Walter
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON DIOXIDE, CHAPARRAL, FERTILIZATION, MICROBE, NITROGEN CYCLE, SOIL

25

Hellstrom, Robert. 2000. Modeling Meteorological Forcing of Snowcover in Forests. *Ph.D. Thesis, Ohio State University, 335 pages.*

The architectural properties of a forest are known to modify significantly meteorological forcing of snowcover. Current numerical snow models utilize a wide range of vegetation representations that limit their application to particular biomes or for basic research on specialized problems. Most do not explicitly represent the combined effects of the canopy on processes of mass and energy transfer beneath the canopy. This project develops forest canopy sub-models that estimate the below-canopy solar and longwave irradiance, wind speed, and accumulation of precipitation, based on meteorological measurements above the canopy and parameters of forest architecture. The wind and solar radiation sub-model predictions were independently compared with meteorological observations at deciduous and coniferous sites in the snowbelt region of northern Michigan. The solar radiation and wind models required adjustments to match sub-canopy measurements. The primary experiment compared the simulations and measurements of snow depth for eight modified versions of the Utah Energy Balance (UEB) snow model during the 1998-99 snowcover season at the two forest sites and a near-by open site. Independent inclusion of each sub-model and a new stability scheme in the UEB model revealed significant

sensitivity of modeled snow depth to stability and each of the four processes estimated by the sub-models. The original UEB model uses a simple forest canopy parameterization that does not consider precipitation interception. Comparison of the original and modified UEB models significantly improved simulations of snow depth at the open and coniferous sites, but performance was slightly worse for a leafless deciduous site. Unlike the modified model, the analysis suggests that the original model produces inconsistent results, which reduces its potential for application to different biomes. Results suggest that opposing processes of energy and mass exchange tend to moderate meteorological forcing beneath a forest canopy. Each process can substantially affect snow depth, depending on the above-canopy meteorological conditions and architecture of the forest. Future work should consider refinement of the sub-models, testing in different biomes, inclusion of soil substrate processes, and comparison of these results with those of other snow models under similar environmental conditions.

Major Professor(s): Arnfield, John
Department: Department of Geography
Principal Investigator(s): Teeri, James A.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: FOREST, MEASUREMENTS, METEOROLOGICAL FORCING, MODEL, SNOWCOVER

26

Henning, Frank Porter. 1995. Effects of Elevated Atmospheric Carbon Dioxide on Carbon and Nitrogen Cycling in Soybean and Sorghum Agroecosystems. *M.S. Thesis, Auburn University, 127 pages.*

The concentration of carbon dioxide (CO₂) in the atmosphere has been rising rapidly since the onset of the Industrial Revolution. Currently, the concentration of CO₂ in the atmosphere is approximately 370 μmol mol⁻¹, and that level is expected to double within the next century. Atmospheric CO₂ supplies nearly all of the carbon © in plant tissues, and thus to the food chains of most life on Earth. Previous research has demonstrated that elevated atmospheric CO₂ stimulates plant growth and increases dry matter yield. Consequently, elevated CO₂ will probably dilute plant nutrient concentrations and increase C inputs to soil systems. A field scale study was conducted to investigate alterations in C and nitrogen (N) cycling in

two soil-plant systems cropped with soybean [*Glycine max* (L.) Merr.] (C₃ species) and sorghum [*Sorghum bicolor* (L.) Moench] (C₄ species). Open top field chambers were used to maintain CO₂ concentrations at ambient (≈360 μmol mol⁻¹) and elevated (≈370 μmol mol⁻¹) during the 1992 and 1993 growing seasons. The study site was an outdoor soil bin which contained a uniform Blanton loamy sand topsoil (loamy, siliceous, thermic, grossarenic Paleudult) located at the USDA-ARS National Soil Dynamics Laboratory on the campus of Auburn University, Auburn, Alabama. Elevated CO₂ increased soybean and sorghum yields and altered many of the parameters used to investigate plant C and N dynamics. Elevated CO₂ had little or no effect on soil C and N concentrations, or on soil microbial biomass. However, soil respiration in plots cropped with soybean and sorghum was greater under elevated compared to ambient CO₂. These data suggest more C entered the soil system, but no more C was stored in soil under elevated than ambient CO₂. In the short-term it appears that greater C is lost from agroecosystems under elevated atmospheric CO₂, which may be explained by shifts in soil microbial communities. In a separate laboratory investigation, Norfolk loamy sand (fine, loamy siliceous, thermic Typic Kandiodult) was amended with soybean and sorghum leaf and stem tissue residues from plants grown under elevated and ambient atmospheric CO₂. Plant litter N concentrations decreased and C:N and lignin:N increased under elevated CO₂, suggesting a decrease in litter quality. However, despite decreased litter quality, C and N mineralization were higher in soils amended with soybean leaf and sorghum stem tissues grown under elevated compared to ambient CO₂. Results from this study indicated that some residue tissues from crops grown under elevated CO₂ may alter microbial community composition and thus enhance soil C turnover.

Major Professor(s): Wood, C. Wesley
Department: Agronomy and Soils
Principal Investigator(s): Rogers, Hugo H.
Program Area: Carbon, Climate, and Vegetation

KEYWORDS: AGRICULTURE, ATMOSPHERE, CARBON CYCLE, CARBON DIOXIDE, CROP, LITTER, NITROGEN CYCLE, PARTITIONING, PRODUCTIVITY, SOIL, VEGETATION

27

Hnilo, Justin J. 1996. A Comparison of GCM and MSU Temperatures for the AMIP Experiment (1979-

1988). *Ph.D. Dissertation, University of Alabama at Huntsville, 256 pages.*

The Atmospheric Model Intercomparison Project (AMIP) was an experiment in which nearly all of the available atmospheric General Circulation Models (GCMs) were systematically driven by a common set of sea surface temperatures (SSTs) over the 1979-88 period. The GCMs of AMIP, given this common forcing, were thus more easily intercompared with one another, and compared with actual observations. In the following study gross measures of tropospheric temperatures were studied in comparison with the tropospheric temperatures observed by the Microwave Sounding Units (MSUs) for the same 1979-88 period. Two measures of temperature from AMIP GCMs were utilized: 1) zonal mean pressure-level temperatures from which a simulated MSU temperature is derived and 2) the 850-200hPa thickness (gridpoint). GCM simulated temperatures were found to have mimicked the general interannual differences, related to El Niño events, quite well. However, a more subtle measure of model variation-decadal trend-showed that in nearly all GCMs, the trend was greater than observed. Most GCMs also demonstrated a thickness response that was less than what was observed; a consequence of GCM atmospheric heating that was deposited too low in the modeled atmospheric column. The appropriateness of using these GCMs as regional climate predictors is questioned as it was found that regional anomalies in the GCMs are often more persistent and severe than those observed in the real world. Therefore, while providing relatively good global and tropical response to SSTs, further GCM improvements are required to more accurately represent decadal trends and regional variations-two key parameters for studying global climate change.

Major Professor(s): Christy, John R.
Department: Atmospheric Science
Principal Investigator(s): Christy, John R.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ATMOSPHERE, CLIMATE, MODEL, REMOTE SENSING, SATELLITE, TEMPERATURE, TEMPORAL DISTRIBUTION

28

Holden, Gerold. 1998. Impact of Increased Atmospheric CO₂ on the Greening of the Sand-Sage Prairie, Finney County Kansas. *M.A. Thesis, Kansas*

State University, 51 pages.

The explosive growth of human population and associated industrial expansion has had far reaching repercussions for the Earth system. Most of the anthropogenic alterations to the environment are detrimental and most are poorly understood. Are human activities changing the climate of the earth? If so, are these changes affecting the vegetative communities found on the landscape? There is a pressing need to answer these questions. Within the broad scope of these questions lies the focus of this study. Atmospheric levels of CO₂ have been rising since continuous data collection began in 1958. This change in atmospheric composition has the potential to alter the climate. For this study Landsat MSS images were used to evaluate change in the vegetative communities of the sand sage prairie in Finney County Kansas from 1972 to 1993. The response of the vegetation to changing environmental conditions was monitored through the use of the Normalized Difference Vegetation Index (NDVI). Although it is evident that the vegetation is responding to its environment, it is questionable as whether atmospheric CO₂ concentrations can be isolated as a cause of increased vegetative vigor due to the overwhelming influence of precipitation. The result of this study was a positive linear regression relationship between NDVI values and atmospheric concentrations of CO₂ as measured at the Mauna Loa collection site.

Major Professor(s): John Harrington, Jr.
Department: Geography
Principal Investigator(s): Harrington, John
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON DIOXIDE, NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI), PRAIRIE, SATELLITE, VEGETATION

29

Horsfall, Fiona M. C. 1996. The Effect of Variable Atmospheric Forcing on Oceanic Subduction of a Passive Tracer in a Numerical Model: Implications for Global Warming. *Ph.D. Dissertation, University of Miami, 230 pages.*

The idealized geometry, isopycnic ocean model of Bleck et al. (Miami Isopycnic Coordinate Ocean Model - MICOM) is used to investigate the oceanic response to changes in atmospheric forcing. The forcing changes

were made to depict changes in the model buoyancy input, momentum input, and turbulent kinetic energy (TKE) input. Each forcing factor was varied uniformly throughout the model domain, separately and together, to examine the oceanic sensitivity, and the possible adjustment of the thermohaline circulation, to a changing climate. The ocean responses examined in this qualitative study are the maximum depth of the mixed layer and the distribution of a passive tracer maintained at 100% in the mixed layer and subducted into the interior and deep ocean by dynamical processes. The model response to the enhanced surface forcing shows wind stress drives lateral advection within the model, which changes subduction rates but not mixed layer depth. Increased air temperatures provide a downward buoyancy flux, which dampens TKE and thus the mixed layer shallows and subduction rates are reduced. An increase in wind speed enhances TKE in the mixed layer which causes the mixed layer to deepen, but does not directly affect subduction rates. The combined effect of more than one forcing mechanism acting together indicates that the individual forcing effects show dominance at different latitudinal regions: wind stress forcing is dominant in mid-latitudes whereas wind stirring and buoyancy forcing are dominant at low and high latitudes within the model domain. The next generation of the model, which includes more realistic topography and a greater model domain, was then used with latitude-dependent atmospheric forcing changes that simulate a global warming scenario, a cooling scenario, and a combination of these representing an alternative warming scenario. The results show the latitudinal dominance of the applied forcing seen in the sensitivity experiments, but in all cases, there is a reduction in the amount of tracer subducted into the interior. The model does not reach a steady state during the integration period, and the data suggests further integration may produce a different result with respect to the amount of tracer subducted in one of the global warming scenario experiments, where the deep ocean gains tracer with time.

Major Professor(s): Bleck, Rainer
Department: Meteorology and Physical Oceanography
Principal Investigator(s): Hanson, Howard P.
Program Area: Computer Hardware, Advanced Mathematics, and Model Physics (CHAMMP)

KEYWORDS: CIRCULATION, CLIMATE, ENERGY FLUX, MIXED LAYER, MODEL, MOMENTUM, OCEAN, SPATIAL DISTRIBUTION, TEMPERATURE, TRACER, WIND

30

Houston, Robb E. 1999. Reconstruction of Eastern Pacific Climate Variability Using Multiple Geochemical Tracers in Cocos Island Corals. *M.S. Thesis, Rice University, 110 pages.*

The tropical ocean-atmosphere climate system plays a key role in regulating global climate variations and despite numerous and intensive studies, the range of natural variability in the tropics remains largely uncertain. Past variations in the climate system must be well established before current environmental trends can be evaluated to make predictions for the future. Corals growing in the shallow tropical ocean may provide some of the answers. Massive coral species can live for centuries, faithfully incorporating chemical and isotopic tracers into their skeletal structure that reflect ambient water conditions. By analyzing variations in the chemical and isotopic composition of cores from such corals, it is possible to reconstruct proxy records of tropical climate variability that extend for the past several decades. However, chronologic control and data interpretations are inhibited by indistinct growth banding, hiatuses, and competing effects of multiple environmental parameters. This study attempts to solve some of the problems of corals-based climate reconstructions by using precise ^{230}Th dating techniques for chronologic control and coupled ^{18}O , Sr/Ca, and U/Ca measurements to try to separate the relative effects of SST and SSS. In addition, Cocos Island is a centrally located open ocean site that will be essential to verify previous results and to construct a regional synthesis of eastern Pacific tropical climate variability.

Major Professor(s): Linsley, Brad
Department: Geology
Principal Investigator(s): Linsley, Brad
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CLIMATE, CORAL, EL NIÑO - SOUTHERN OSCILLATION (ENSO), ISLAND, OCEAN, TEMPORAL DISTRIBUTION, TROPICS

31

Hu, Tianmiao. 1998. A Study of Applying Artificial Neural Network Techniques to Regional Climate Downscaling under Global Climate Change. *M.S. Thesis, Tulane University, 95 pages.*

In this thesis feedforward neural networks were successfully used for regional temperature and wind

speed downscaling. A semi-empirical downscaling approach similar to an approach widely used in the weather forecast community was adopted. Free atmospheric output from the Community Climate Model (CCM1) and observational regional surface variables were used to generate the empirical models and future predictions. The strength of this approach is that the large-scale atmospheric forcings were accounted for by the CCM1 and the mesoscale forcings were accounted for by the empirical models. In temperature downscaling the neural network approach gave similar results to those from the multiple linear regression approach. Both approaches significantly improved the original CCM1 predictions. While the previous multiple linear regression approach had to resort to seasonal models with smoothed data in temperature downscaling, the neural network approach could produce a single yearly model with unsmoothed data. The strong modeling ability of the neural network was demonstrated by its regional wind speed downscaling where the multiple linear regression approach failed to generate useful models. In conclusion, neural networks are powerful alternatives to statistical tools and are very suitable for analysis of complex systems like those of the global climate.

Major Professor(s): Sailor, David
Department: Mechanical Engineering
Principal Investigator(s): Sailor, David
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CLIMATE, DOWNSCALING, MODEL, NEURAL NETWORK, REGIONAL ANALYSIS

32

Hubbard, Carter. 1998. Hydrologic Modeling of the Missouri River Basin in a Climate Change Model. *M.S. Thesis, University of Nebraska-Lincoln, 531 pages.*

A computer model of the Missouri River basin has been developed to simulate climate change impacts on water resources in the Great Plains. The model is based on the SWAT (Soil and Water Assessment Tool) hydrologic code developed by the Agricultural Research Service (ARS) and the Texas Agricultural Experiment Station (TAES). The input data set for the model was obtained from the HUMUS (Hydrologic Unit Modeling of the United States) project. Modifications were made to the SWAT model (Jorgensen, 1996) to simulate the operation of the six main stem reservoirs on the Missouri River. The reservoir algorithms effectively

simulate the operating procedures used by the Missouri River Region of the U.S. Army Corps of Engineers. Climate change data sets were provided by the National Center for Atmospheric Research. Using historical climate data and climate change data for 2xCO₂ climate conditions, simulations of the SWAT model were run. Impacts of climate change on the spatial and temporal distribution of water resources and agricultural production were evaluated by comparing differences in outputs between the baseline and double CO₂ simulations. Results indicate overall water yield from the Missouri River basin will decrease for 2xCO₂ climate conditions. Results also indicate that an additional 1.5 million hectare-meters of water will be available annually in the main stem reservoir system for 2xCO₂ climate conditions. The water could be diverted from the reservoirs for use in the surrounding agricultural areas in South and North Dakota, Montana, and Nebraska. Main stem reservoir system inflows for baseline climate conditions show SWAT consistently underpredicts water yield values in the northern Missouri River basin. The model responds to changes in inputs but simulated runoff values are consistently low. Work is being performed to improve precipitation lapse rate and snowmelt algorithms for mountainous regions of the Missouri River basin. These improvements should allow a full analysis of climate change impacts and management strategies.

Major Professor(s): Hotchkiss, Rollin H.
Department: Civil Engineering
Principal Investigator(s): Hotchkiss, Rollin H.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON DIOXIDE, CLIMATE, HYDROLOGY, MODEL, RIVER, RUNOFF, SPATIAL DISTRIBUTION, TEMPORAL DISTRIBUTION

33

Jorgensen, Steven F. 1996. Hydrologic Modeling of Missouri River Reservoirs in a Climate Change Model. *M.S. Thesis, University of Nebraska at Lincoln, 109 pages.*

A computer model of the Missouri River basin has been developed to simulate the impacts of climate change on water resources in the Great Plains. It uses the hydrologic model SWAT (Soil and Water Assessment Tool) developed by the Agricultural Research Service (ARS) and the Texas Agricultural Experiment Station (TAES). The data for the initial model was obtained

from the HUMUS (Hydrologic Unit Modeling of the United States) project also developed by the ARS and TAES, funded through the Natural Resources Conservation Service. New algorithms were compiled in the model to simulate operation of the six main stem reservoirs on the Missouri River in Montana and South Dakota. These were developed to investigate the potential of the reservoirs to mitigate effects of global climate change. The reservoir algorithms effectively simulate the operating procedures used by the Missouri River Division of the Corps of Engineers. The routines seek to maintain the reservoirs in the normal operation range by monitoring total system storage and individual reservoir storage and adjusting outflow accordingly. A simplified version of the HUMUS dataset was compiled and calibrated for use in testing the reservoir routines. The algorithms were successfully implemented and tested in this model. The reservoir subroutine reproduced system storage and reservoir release rates very well using historical data. Further, simulations with logical bounds showed that the routines perform well for many ranges of input. The computer model is now prepared for further development and the simulation of the effects of climate change in the region including economic analyses, adaptation scenarios, and mitigation scenarios.

Major Professor(s): Hotchkiss, Rollin H.
Department: Civil Engineering
Principal Investigator(s): Hotchkiss, Rollin H.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CLIMATE, HYDROLOGY, LAKE, MODEL

34

Keightley, Keir Edward. 1999. Mapping Productivity and Boundary Layer Conditions Using the Airborne Visible and Infrared Imaging Spectrometer. *M.A. Thesis, University of California, 103 pages.*

In the past 30 years research has sought to measure and model the physiology of naturally occurring vegetation from the scale of stoma to the scale of the entire planet. Review of the relevant body of literature reveals the complexity of this task. The objective of this research is to use high spatial resolution imaging spectrometer data to establish a relationship between atmospheric water vapor and the corresponding underlying vegetation and to investigate the feasibility of generating realistic estimates of boundary layer

conditions. Ultimately, this and other research is intended to provide accurate estimates of terrestrial carbon and energy flux as well as indications of biologically active trace gas flux from the scale of the plant organ to the continent and entire planet. These in turn can be used to monitor environmental change. AVIRIS data of a site in Southern Washington State were processed to produce water vapor, liquid water and reflectance products. This was done for three separate dates during the summer months of 1996 and 1997. These products were then used in combination with USGS 30-meter DEM and surface temperature measurements to generate regional maps of 'anomalous' water vapor. Statistical analysis revealed that for forested areas, stands of old growth forest were associated with significantly greater amounts of atmospheric water vapor than were stands of second growth (previously harvested) forest. The surface meteorological data and water vapor data were integrated to calculate boundary layer parameters that influence evapotranspiration and respiration. No attempt was made to quantify the forest productivity in relation to the measured vapor anomalies due to the lack of data describing the near-surface distribution of water vapor and the lack of productivity control site data. The technique developed has the potential to provide an alternative approach to the vegetation indices currently used as input to regional ecophysiological modeling for the remote detection of physiological activity (e.g. photosynthesis). This technique provides, as well, the spatial resolution to link small scale (tree to stand) research results with regional scale (watershed to biome) modeling.

Major Professor(s): Roberts, Dar A.
Department: Geography
Principal Investigator(s): Roberts, Dar A.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ATMOSPHERE, BOUNDARY LAYER, EVAPOTRANSPIRATION, FOREST, LAND SURFACE, MODEL, RESPIRATION, WATER VAPOR

35

Khisty, Mohan. 1996. Simulation of the Shift in Position of Hinge Lines Between Two Lakes. *M.S. Thesis, University of Nebraska at Lincoln, 40 pages.*

Groundwater flow between two hypothetical, shallow, flow-through lakes was numerically simulated in steady state and transient conditions for two cases. In the first

case the lakes are at identical surface water elevations and in the second case there is a small difference in surface water elevations between them. Simulation results from both cases indicate a direct relation between movement of hinge lines, which indicate changes in the direction of groundwater-lake seepage components, and the seasonal persistence and decline of a groundwater mound that exists between the two lakes. A comparison between steady-state simulation results for both cases indicates that a small difference in surface water elevation between two lakes results in differences between the relative proportions of groundwater-lake seepage components of the two lakes and is reflected in the difference in position of hinge line locations between the two lakes. A comparison between transient simulation results for both cases shows that the small difference in surface water elevations between two lakes results in a fairly constant difference in the rates of groundwater-lake seepage components. Hinge line positions between the two lakes also maintain a fairly constant difference in position during the course of the simulation. Lake level fluctuations produced by the model compare well with the range and seasonality of actual lake level fluctuations on which the modeled system is based. Simulation results establish the usefulness of the lake package addition to MODFLOW in simulating groundwater-lake interactions involving multiple lakes. Further, these results provide guidance in locating sampling wells because the bounds of hinge line traverse, for each lake, delineates a zone of transition characterized by groundwater-lake flow reversals.

Major Professor(s): Gosselin, David C.
Department: Geology
Principal Investigator(s): Gosselin, David C.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: FLOW, HYDROLOGY, LAKE, LAND SURFACE, SPATIAL DISTRIBUTION

36

Klassen, Jane F. 1997. Climate Change Impacts on the Hydrology of Spring Creek Basin in the Black Hills of South Dakota Using Soil and Water Assessment Tool. *M.S. Thesis, South Dakota School of Mines and Technology, 67 pages.*

An increase in atmospheric CO₂ levels and temperature from a changing global climate may affect the availability of water on and beneath the earth's surface.

Changes in water availability in the north central United States are expected to be particularly critical because water availability is limited. Therefore, the physical hydrologic processes need to be well understood in order to determine the consequences of climate change on regional water resources. The objective of this paper is to evaluate the ability of the hydrologic modeling program called Soil and Water Assessment Tool (SWAT) to simulate the hydrologic response of a pine forest watershed located in the steep sloping terrain of the Black Hills of South Dakota. This paper also evaluates the models sensitivity to potential climate change effects. The calibration results show that the coefficient for linear regression, r^2 , between the actual annual water yield and the calibrated model is 0.94. The results of the climate change sensitivity analysis show increased annual water yield of up to 74% due to doubled atmospheric CO₂, up to 110% due to increased precipitation, and decreased annual water yield of up to 75% due to increased temperature and 63% due to decreased precipitation. From both the climate change models, it appears that evapotranspiration, which includes both leaf photosynthesis processes and soil moisture processes, could become a limiting or contributing factor in the amount of annual water yield from the watershed under climate change conditions. Changes in precipitation due to climate variations would also have an effect on the evapotranspirational processes of the forest, in turn contributing to an increase or decrease in annual water yield from the basin.

Major Professor(s): Fontaine, Thomas A.
Department: Civil and Environmental Engineering
Principal Investigator(s): Hotchkiss, Rollin
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CLIMATE, HYDROLOGY, MODEL, RUNOFF, WATER

37

Lightsey, Jack Wilson I. I. I. 2000. Input Preparation and Execution of the PnET-IIS Hydrological Model on the Six-Digit HUCs of the Southeast. *M.S. Thesis, University of Alabama, Tuscaloosa, 83 pages.*

The PnET-IIS model is a coupled photosynthesis, productivity, and hydrological model designed to project regional forest changes from observed monthly time step data. It is capable of predicting runoff for a watershed on the basis of climatic, soil, and vegetation

inputs. Comparisons of runoff predictions for the past, present, and future is a way of predicting the impacts of global climate change. The research described in this thesis consists of two major parts. The first of these concerns validation of the PnET-IIS model, and the second concerns input preparation for execution of the model for the entire southeastern United States. The first stage of this research focused on validation of the PnET-IIS model as a tool for predicting runoff from a watershed based on necessary model input parameters. The model was first validated on 12 test sites within the southeastern United States. These sites were chosen based on spatial distance from one another, dominant forest type, and digital input availability. Once the necessary model inputs had been assembled, execution of the PnET-IIS model on these sites was performed. This allowed for comparisons with existing historical streamflow data provided by the United States Geological Survey (USGS). The second stage of this research focused on input preparation for each of the 144 6-digit hydrological unit codes (HUCs) that comprise the southeastern United States. Individual GIS databases were constructed from various internet sites for the inputs necessary to perform PnET-IIS runs. Compilation, modification, and storage of the inputs were then carried out using the GIS software ArcInfo and ArcView. Input files created using these tools will provide the basis for future PnET-IIS runs to assess the implications of potential climate change for the water resources of the southeastern United States.

Major Professor(s): Durrans, S. Rocky
Department: Civil and Environmental Engineering
Principal Investigator(s): Abt, Robert C.
Program Area: National Institute for Global
Environmental Change (NIGEC)

KEYWORDS: CLIMATE, FOREST, HYDROLOGY,
MODEL, PHOTOSYNTHESIS, PRODUCTIVITY,
RUNOFF, SOIL, VEGETATION

38

Liptay, Karen. 1998. The Use Stable Isotopes to Constrain Anthropogenic Methane Sources: Coal Mines and Landfill. *M.S. Thesis, Florida State University, 121 pages.*

Seasonal variations in the oxidation of methane during its transport across the soil cap of a landfill in Leon County, Florida USA were determined in situ with a stable isotopic technique. The approach contrasted the $\delta^{13}\text{C}$ values of emitted and anoxic zone CH_4 and

utilized measurements of the isotopic fractionation factor (α) which varied inversely with temperature from 1.025 to 1.049. Anoxic zone CH_4 did not vary seasonally and had a $\delta^{13}\text{C}$ average value of $-55.18 \pm 0.15\text{‰}$. Methane emitted from the landfill soil surface and captured in chambers ranged in $\delta^{13}\text{C}$ from -54‰ in winter, when emission rates were high to -40‰ in summer when emission rates were lower. The antipathetic variation between the $\delta^{13}\text{C}$ of emitted CH_4 and the rate of CH_4 emission is consistent with control of the emission rate by bacterial oxidation. Our interpretation of the isotope data indicates that methane oxidation consumed from 3 to 5% of the total flux in winter, to a maximum of $43 \pm 10\%$ in summer. There was variation in the extent of methane oxidation in soil types with mulch/topsoil averaging $55 \pm 14\%$, and clay averaging of $33 \pm 13\%$ in summer. The seasonally integrated value for methane oxidation for areas of the landfill covered with mulch/topsoil was $26 \pm 4\%$ of the flux towards the soil surface, while for clay soil it was only $14 \pm 2\%$. The overall annual average which includes both types of soil was $20 \pm 3\%$. Covering landfills with additional mulch, which can be generated from yard waste, may attenuate methane emission by providing a loose non-compact substrate for bacterial attachment and an environment with moisture, methane and oxygen. At specific sites within the landfill we studied, temperature was the main factor controlling methane oxidation. Models for the global methane budget use stable isotopic signature to constrain methane sources. The current value for coal mines (-37‰) is based on a review of studies done in the 1960's and does not include methane from ventilation systems. Coal mine samples for this study were taken from four basins in the USA for a total of 78 samples. The average value for our sites was $-51 \pm 7\text{‰}$ a value more depleted than previously recorded. Our study shows that coal basin of the USA have unique isotopic signatures and that the isotopic ratio used in models should be less enriched than the current value.

Major Professor(s): Chanton, Jeffrey P.
Department: Oceanography
Principal Investigator(s): Chanton, Jeffrey P.
Program Area: National Institute for Global
Environmental Change (NIGEC)

KEYWORDS: ATMOSPHERE, LANDFILL, METHANE

39

Liu, Shuguang. 1996. Evapotranspiration from Cypress (*Taxodium ascendens*) Wetlands and Slash

Pine (*Pinus elliottii*) Uplands in North-Central Florida. Ph.D. Dissertation, University of Florida, 258 pages.

In order to investigate the difference, if any, of evapotranspiration between cypress wetlands and slash pine uplands, the rainfall interception, evaporation from water surface, transpiration and stomatal conductance at the leaf/needle level, leaf area index, soil moisture and water table fluctuations were measured in three cypress (*Taxodium ascendens*) wetlands and their surrounding slash pine (*Pinus elliottii*) plantations from April 1993 to March 1994 near Gainesville, Florida. The feasibility and potential methods of estimating evapotranspiration from water table fluctuations were appraised and developed. A multi-species and multi-layer evapotranspiration model at ecosystem level, ETM, was developed in order to simulate the change of evapotranspiration and its components (i.e., transpiration, rainfall interception, and evaporation from water or soil surface) under various environmental and biological conditions. The transpiration submodel, which scales transpiration up from the leaf/needle level using the acquired stomatal conductance data and information about stand structure and micrometeorology, was verified with field scale measurements obtained in a slash pine plantation by an eddy-correlation method. There were no empirical parameters in the newly-derived interception submodel, which was tested by field measurements and compared with Gash and Mulder models using data from the literature. A submodel of evaporation from open water surfaces was also developed, based on field measurements. There was no significant difference ($\alpha = 0.05$) between cypress and slash pine with respect to transpiration and stomatal conductance at the leaf level during the growing season. No significant difference ($\alpha = 0.05$) has been detected in terms of annual transpiration, rainfall interception and total evapotranspiration between cypress wetlands and slash pine uplands. Therefore, the difference in evapotranspiration between cypress wetlands and slash pine uplands was primarily determined by the magnitude of water surface evaporation in wetlands, which could be as high as 500 mm per year or about 1/3 of the potential evaporation.

Major Professor(s): Riekerk, Hans
Department: School of Forest Resources and Conservation
Principal Investigator(s): Gholz, Henry L.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CONDUCTANCE, EVAPORATION,

HYDROLOGY, LEAF AREA INDEX (LAI), MODEL, STOMATE, TRANSPIRATION, VEGETATION, WETLAND

40

Lombardi, Joanne E. 1999. A technique for carbon isotopic analysis of rhizospheric methane oxidation and atmospheric methane. Ph.D. Thesis, Florida State University, 196 pages.

The objectives of this dissertation were to constrain estimates of rhizospheric methane oxidation in detailed greenhouse and field studies and to evaluate the gas chromatograph isotope-ratio mass spectrometer for determination of excess CH₄ over ambient air. Significant differences were observed for rhizospheric methane oxidation between greenhouse and field studies. In the greenhouse, oxidation percentages were 62% while only 26% and 40% were determined in the field. Differences were associated with higher root density in greenhouse plants, which was caused by potting effects and fertilization. To model methane oxidation in the rhizosphere, turnover times and the concentration and d¹³C signatures of sedimentary, lacunal, and emitted CH₄ were measured. Fractionation factors for rhizospheric methane oxidation were calculated to be 1.021 for greenhouse rhizosphere soil and ranged from 1.041-1.018 for two field sites. Using a transport reaction model, the measured d¹³C and concentration values for the field were reproduced. To reproduce the field data, production and oxidation zones had to be in close contact with each other, produced methane had to be significantly ¹³C depleted relative to sedimentary methane, and a fractionation factor for rhizospheric methane oxidation greater than 1.015 had to be applied. Differences in produced and bubble methane were a result of fractionation due to methane oxidation and transport from the oxidation zone into the plant. The results of the model application indicate that rhizospheric methane oxidation occurs not along the rhizoplane, as has been generally assumed, but in the bulk sediment or rhizosphere, supported by O₂ leakage from the plant roots. The precision and accuracy of the GC-IRMS system operated with a cryogenic pre-concentration device allowed determination of the source of excess methane over and above clean background ambient air at several sites. Excess CH₄ in the air at a swamp forest tower was within range of the sedimentary CH₄ at the site, even though the methane concentration in the air samples was elevated by only 0.3 ppm or less. Air collected at four sites in the northeastern USA

contained excess methane from such sources as combustion, landfill methane emission and biogenic methane.

Major Professor(s): Chanton, Jeffrey P.
Department: Chemistry
Principal Investigator(s): Chanton, Jeffrey P.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: METHANE, OXIDATION, ROOT

41

Mansfield, Jennifer. 1996. Genotypic Variation for Condensed Tannin Production in Trembling Aspen (*Populus tremuloides*) under Elevated CO₂ and in High and Low Fertility Soil. *M.S. Thesis, Ohio State University, 30 pages.*

The Carbon/Nutrient Balance Hypothesis suggests that leaf C:N ratios influence the synthesis of secondary compounds such as condensed tannins. Levels of CO₂ are rising in the atmosphere, resulting in increased C:N ratios in leaves. Six genotypes of *Populus tremuloides* were grown under elevated and ambient CO₂ partial pressure and high and low fertility in field open-top chambers at the University of Michigan Biological Station. During the second year of exposure, leaves were harvested three times (June, August, and September) and analyzed for condensed tannin production. Significant genotype, fertility and CO₂ effects as well as a significant genotype by CO₂ interaction were found. The Carbon Nutrient Balance Hypothesis was supported overall, but not all genotypes responded in the same way to the CO₂ treatment. Some genotypes increased tannin production at elevated compared to ambient CO₂ while others showed no CO₂ response. These results suggest that with rising atmospheric CO₂, plant secondary compound production may vary within species. This could have consequences for plant-herbivore and plant-microbe interactions, as well as the evolutionary response of this species to global climate change.

Major Professor(s): Curtis, Peter
Department: Plant Biology
Principal Investigator(s): Curtis, Peter
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON DIOXIDE, FERTILIZATION, LEAF, SOIL

42

Mays, Kennetha. 1996. Photosynthetic Responses of Quaking Aspen, *Populus tremuloides*, Genotypes under Elevated CO₂ and in High and Low Fertility Soils. *M.S. Thesis, Ohio State University, 42 pages.*

Plants often increase their photosynthetic rate under elevated CO₂ conditions but this response may be limited by low soil fertility levels. To determine the photosynthetic response of quaking aspen genotypes to elevated CO₂, with and without nutrient stress, trees were grown from root cuttings for 15 months under 35 or 70 Pa CO₂ in soils of low or high N fertility in open top chambers at the University of Michigan Biological Station. Light saturated net CO₂ assimilation was measured three times over a single growing season using a portable infrared gas analyzer, or IRGA. All plants were measured at both 35 and 70 Pa CO₂. Genotypes were organized into two groups according to timing of leaf drop. In June at the CO₂ X soil fertility phenotypes, all phenotypes responded positively to increased CO₂, but only in the high fertility soil treatment. In June and August, early leaf drop phenotypes responded positively at both levels of soil fertility while late leaf drop phenotypes responded positively only at high soil fertility. In September, using 27 Pa to measure negative adjustment early leaf drop phenotypes grown at elevated CO₂ and low soil fertility had significantly downregulated photosynthetic capacity while late leaf drop phenotypes had not. When using 56 Pa to measure negative adjustment no downregulation took place. Our data indicated that high CO₂ stimulation of photosynthesis in quaking aspen was sensitive to soil fertility but that this sensitivity varied temporally and according to plant phenotype.

Major Professor(s): Curtis, Peter
Department: Plant Biology
Principal Investigator(s): Curtis, Peter
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON DIOXIDE, FERTILIZATION, PHOTOSYNTHESIS, SOIL, STOMATE, VEGETATION

43

Montes-Helu, Mario. 1997. Tracked Vehicle Disturbance in a Rangeland and Design of Sapflow Gauges for Desert Shrubs. *Ph.D. Dissertation, New Mexico State University, 300 pages.*

Rangelands of the arid southwest are used extensively for military training. The impact of track-vehicle traffic on the Ft. Bliss military reservation were evaluated in soil water balance. Military training can reduce vegetation and accelerate erosion. Sustainable management will result from balancing disturbance intensity with recovery times. Military activities can occur during all seasons and the possible impact in the ecology can vary. Season and soil types produce different impact. The objectives of this study were to measure the soil disturbance caused by track-vehicles and the resulting change in site water balance. Soil disturbance was analyzed with the change in the bulk density, microrelief and erosion rods. Bulk density changed (increased) depending the number of tank passes and season. The surface micro-topography was modified by the tank and remained months after the tank passed. Erosion rods showed soil removal and deposition. Water storage increased about one to 2 cm for 5 pass treatments in one site. There was a slight increase of water storage right after the tank because the destruction of the vegetation reducing plant transpiration. The Penman method estimated a lower potential evapotranspiration (PET) values than expected under irrigation conditions. Dry soil surface and low vegetative covers produced low net radiation. A relationship between total rain and runoff measures was used in the water balance to estimate runoff. The overall water balances, assuming zero drainage shows that all the rain was used in ET. The actual evapotranspiration (AET) was about 15% of PET. During the growing season the AET is 0.25 cm day^{-1} in the wettest sites. Dry sites had a maximum AET of 0.15 to 0.20 cm day^{-1} . Direct measurement of plant transpiration has always been a problem under natural conditions. One way to estimate of plant transpiration is the heat balance method. This is an application of heat and accounting the heat input and output used to measure the water flow assuming steady-state conditions. The main objective was design a sap flow gauge that can regulate the quantity of heat required depending on sap flow conditions and avoid the stem damage by overheating when there is low flow. Controlling heat input to maintain constant temperature difference keeping steady-state condition does not appear to damage the stem. The simple design does not allow adequate correction for conduction losses. The three thermocouple design allows correction for conduction losses. However, calibrations before installation in the field are not possible. Portable heat balance design allows laboratory calibrations before field installation. There was a good agreement between the measurements and the calculated water flux under laboratory conditions. Under greenhouse conditions,

the heat balance method calculated the water flow in potted pecan plants quite well when compared with measured water loss.

Major Professor(s): Jones, Timothy L.
Department: Agronomy and Horticulture
Principal Investigator(s): Gutschick, Vincent
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: *DISTURBANCE, EVAPORATION, FLOW, LAND SURFACE, PRECIPITATION, RUNOFF, SAP, SOIL, TRANSPIRATION, WATER*

44

Munoz, Ricardo. 1997. Energy Sector Sensitivity to Climate and Climate Change. *M.S. Thesis, Tulane University, 60 pages.*

In this work methodologies for determining the climate sensitivity of the energy sector are developed. In addition, the potential impact of climate change on energy supply and demand is assessed using various case studies. In the demand side, models that relate per capita electricity and natural consumption to degree days and temperature respectively were developed for eight key states of the U.S. The final models are quite robust, with R-square parameters generally larger than 0.8. These models predict increases in electricity consumption up to 20% for increments in temperature of 3°C . Natural gas consumption will decrease significantly under climate change at a rate proportional to the exponential of the temperature increase. In the supply side, the Sacramento, Eel and Russian rivers basin was used as an example of the implementation of the methodology we developed. The final model relates the total hydrogenating availability in any given season to present and past (as far back as five seasons) basic climatic parameters. Possible impacts of climate change on hydrogeneration for the basin depend strongly on the accuracy of climate change predictions, especially precipitation levels. The climate change scenarios used in this work are within climate predictions given by General Circulation Models, however. Finally, recommendations that could lead to conceptual improvements and to increased predictive capabilities of the models were made.

Major Professor(s): Sailor, David
Department: Mechanical Engineering
Principal Investigator(s): Sailor, David
Program Area: National Institute for Global

KEYWORDS: CLIMATE, ENERGY USE, MODEL, TEMPERATURE

45

Osborn, Timothy J. 1995. Internally-Generated Variability in Some Ocean Models on Decadal to Millennial Timescales. *Ph.D. Thesis, University of East Anglia, 650 pages.*

Passive variability, generated by the modulation of random weather events by the inertia of the oceans, is studied with a range of simple ocean models of the upwelling-diffusion type. Earlier work is extended by parameterising global-mean vertical heat transport in a number of depth-dependent and time-dependent ways. These are developed from theoretical and empirical considerations, as well as from comparison with a more complex ocean general circulation model (OGCM). They are an attempt to separate the effects of isopycnal and diapycnal advection and diffusion. The spectra of passive variability is shown to be sensitive to these parameterisations. The highest sensitivity is to the replacement of a completely mixed layer by a layer of enhanced mixing, which results in all the combinations tested exhibiting weaker low frequency variability than some previous studies found. Active variability, generated by instabilities and interactions within the ocean and between ocean and atmosphere, requires more complex ocean models which explicitly model ocean dynamics. Previous work, which found considerable Southern Ocean and Atlantic Ocean variability in the LSG OGCM under mixed boundary conditions, was extended in a number of ways. First, a similar experiment was performed, but with a rather different OGCM. Numerical problems greatly reduced the usefulness of the results. Second, the sensitivity of the internal variability to some of the model's physical and numerical details was investigated. Using an alternative convective adjustment scheme can reduce the magnitude of the internal variability by 70%. Using an improved parameterisation of brine rejection from sea-ice freezing also reduced the magnitude of variability, although stronger stochastic forcing could induce large North Atlantic oscillations. Third, it was shown that the dominant variability was purely a Southern Ocean phenomenon, since the signals which propagate around the Atlantic Ocean play no active role in that mode. A second type of propagation was identified - westward around the Antarctic continent - and was explained as a coupled 'salinity - coastal

upwelling' wave motion. Finally, the active variability of a hybrid coupled model was studied. This model consisted of the same OGCM, but coupled to a statistical atmosphere model rather than to mixed boundary conditions. The atmosphere model was constructed on the basis of results from a 19 year simulation with an atmosphere general circulation model forced by observed sea surface temperatures. It included active air-sea fluxes of fresh-water, momentum and heat. The fresh-water flux model appeared to reduce the magnitude and period of the ocean variability, but this was shown to have little significance. In fact, when the statistical model was improved it acted to slightly strengthen and lengthen the oscillation maxima and minima. The air temperature (i.e., heat flux) model weakened the convective feedback which causes the model's variability, so that the oscillations were weaker. But it was unable to prevent the variability from occurring, and was unable to prevent a partial collapse of the North Atlantic thermohaline circulation under stronger forcing.

Major Professor(s): Wigley, Tom M. L.
Department: School of Environmental Sciences
Principal Investigator(s): Wigley, Tom M. L., and Philip D. Jones
Program Area: Carbon, Climate, and Vegetation

KEYWORDS: CIRCULATION, FLOW, FLUX, HEAT, MODEL, MOMENTUM, OCEAN, SALINITY, SPATIAL DISTRIBUTION, TEMPERATURE, TEMPORAL DISTRIBUTION

46

Pacheco, Gerardo. 1996. Empirical Modeling of Timber Supply in the U.S. South. *Ph.D. Dissertation, North Carolina State University, 215 pages.*

Periodic assessments from the USDA Forest Service analyze the timber resource situation and project the changing resource conditions, providing information used to formulate policy changes or identify opportunities for public or private investment at the national level. Recent wider data availability has allowed modelers in the South to produce alternative projections to the national assessments given concerns about reliability of state and substate projections from national models. The three papers in this research deal with data and modeling issues in the modeling of timber supply for the US South. Chapter 1 characterizes the US South forest resource from the

perspective of empirical timber supply modeling. Summaries of relevant timber supply indicators at the South-wide, state, and survey region level, for the common forest types, species groups, and ownerships are provided as guidelines for the commonly used levels of aggregation in modeling. An assessment is made of the use of Eastwide data base data from the USDA Forest Service for timber supply modeling. Insights provided may be relevant to the modeling process and to the elaboration of assumptions. The information provided can contribute to the development of improved models and it might be useful to resource analysts in industry, government, and universities. Results from a South-wide timber supply projection to the year 2020 are examined and compared against national projections in chapter 2. Using the latest FIA survey unit data for the South (excluding Kentucky and public ownerships) individual state inventories were updated to 1994 as a common starting point for the projection. Only private ownerships were considered in the model. Softwood prices are projected to increase seven times and hardwood prices over two and a half times over the projection period. The largest projected price increases for softwoods occur during the decade 2010 to 2020. Inventory of softwoods is projected to decrease by 30% relative to the starting year, and hardwoods to increase only slightly by 2%. South-wide softwoods growth to removal ratio is expected to decline from 0.94 to 0.71, and from 1.36 to 0.87 for hardwoods. Price projections are sensitive to growth per acre assumptions. The results in this paper are conservative in that they assume constant productivity levels in planted pine forest types. Chapter 3 examines the effects of differing assumptions about the future productivity levels of pine plantations. Empirical models of growth and yield are developed for each of the major forest types in the US South with the purpose to evaluate the impact on empirical timber supply projections from possible increases in the productivity of pine plantations of 20%, 40% and 60% by the year 2020. The resulting equations were used to generate data and to modify the empirical timber supply model SERTS. Total increases of 60% in pine plantation growth per acre by the end of the projection results in total softwood price increases (174%) that are less than one fourth of those produced by the base projection (788%). Improved projections can be made with better quality and availability of data on projected pine plantation areas and the extent of current and projected level of intensive management in pine plantations.

Major Professor(s): Abt, Robert C.
Department: Forestry
Principal Investigator(s): Abt, Robert C.

Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: *ECONOMICS, FOREST, GROWTH AND DEVELOPMENT, MODEL, PRODUCTIVITY, REGIONAL ANALYSIS*

47

Pantoja, Silvio. 1997. Reactivity of Proteins, Peptides and Amino Acids in the Marine Environment: Effects of Molecular Size and Structure on Degradation. *Ph.D Dissertation, State University of New York at Stony Brook, 279 pages.*

This dissertation investigates basic principles of reactivity of organic matter, focusing on amino acids, peptides and proteins as model compounds. I explore the lability of these compounds in seawater and sediments, the relationship of degradation rate and extent to chemical structure, and the changes in molecular size of the compounds with depth in sediments. Microbial degradation of proteins and peptides in the ocean is thought to proceed via extracellular hydrolysis to oligopeptides and amino acids, which can be subsequently mineralized. A new approach to studying extracellular hydrolysis of peptides in seawater and sediments was developed by synthesizing fluorescent peptide substrates of varying length and with different amino acid constituents. It was shown that extracellular peptide hydrolysis in seawater and sediments does not proceed in a random manner, but at specific peptide linkages, and that size and structure of peptides influence hydrolysis rates. Hydrolysis of dipeptides was slower than of longer peptides; kinetics of these reactions suggest the occurrence of multiple hydrolytic enzymes in seawater and sediment, each with different specificity. Laboratory incubations suggest that performance of these hydrolytic enzymes under different environmental may cause preferential degradation of certain substrates. Consistent with their role as a link between protein deposition and microbial mineralization in sediments, field observations suggested that extracellular hydrolysis of peptides could supply most of the consumed free amino acids consumed. Protein is a reactive fraction of the nitrogen pool and can account for most of the NH_4^+ produced in coastal sediments. In field experiments off the coast of Chile, rate constants for protein decomposition were among the highest reported for marine sediments. In Long Island Sound sediments, the magnitude of the protein decomposition rate constant was affected by deposition of labile

substrate and biological benthic activity. Enrichment of larger proteins was detected in deeper sediments, suggesting selective preservation, adsorption or condensation with other resistant organic matter.

Major Professor(s): Lee, Cindy
Department: Coastal Oceanography
Principal Investigator(s): Aller, Robert C., Josephine Aller, Cindy Lee, and J. Kirk Cochran
Program Area: Marine Transport

KEYWORDS: COASTAL ENVIRONMENT, DEGRADATION, ORGANICS, SEDIMENT, SPATIAL DISTRIBUTION, WATER

48

Pontius, Robert G., Jr. 1994. Modeling Tropical Land Use Change and Assessing Policies to Reduce Carbon Dioxide Release from Africa. *Ph.D. Dissertation, State University of New York at Syracuse, 177 pages.*

Humans could be causing the climate to change in ways that could threaten the welfare of future generations. The alteration by humans of the earth's remaining tropical forests is a component of the atmospheric flux of carbon dioxide, the most important greenhouse gas. It is especially important to investigate this flux because our understanding of it is highly uncertain, and it is a component of the global carbon cycles that humans can regulate. This dissertation supplies scientific tools and socioeconomic insights that policy makers may use to help to decide how much, if at all, to reduce the anthropogenic release of carbon dioxide from tropical landscapes. Chapter 1 presents a new GIS model called GEOMOD2, which is a computer program written in FORTRAN. GEOMOD2 simulates land use change forward and backward in time using a digital map of land use, and produces a map of simulated carbon dioxide flux due to land use change. GEOMOD2 selects land for conversion according to patterns of previous land use and rates of change. Chapter 1 applies GEOMOD2 to tropical Africa, but the model could be used in other parts of the world and for a wider variety of applications. Chapter 2 uses the kappa parameter and an extraordinarily complete data set for Costa Rica to examine the accuracy with which GEOMOD2 predicts land use patterns. GEOMOD2 simulates the pattern of land use in Costa Rica over a duration of more than four decades with a success rate between 74% and 84% (kappa between 0.32 and 0.44). Chapter 3 uses an ecological economics approach to assess policies to reduce the amount of carbon dioxide

being released from African agriculture. It concludes that the application of fertilizer to existing African fields would supply additional needed food to Africans at a minimum carbon dioxide release, compared with other methods such as food importation, expanded shifting cultivation, or newly created permanent cultivation.

Major Professor(s): Hall, Charles A.S.
Department: Graduate Program in Environmental Science
Principal Investigator(s): Hall, Charles A.S.
Program Area: Carbon, Climate, and Vegetation

KEYWORDS: CARBON CYCLE, EMISSION, LAND USE, MODEL, POLICY, TROPICS

49

Pressley, Shelley Noelle. 1999. Biogenic Hydrocarbon Emissions from an Old Growth Forest and a Poplar Plantation. *M.S. Thesis, Washington State University, 94 pages.*

Measurements of natural hydrocarbon emission fluxes are reported for an old growth Pacific Northwest coniferous forest. The emission data were collected for the two dominant species (Douglas fir and western hemlock) during the growing season in 1997 and 1998 using a branch enclosure technique. Monoterpene emissions were standardized to 30°C by block-averaging the data into 2°C temperature intervals and using an emission algorithm $E(T) = E_s \exp[\beta(T-T_s)]$. Combining all samples from both years, the standard emission rate for Douglas fir is $E_s = 0.39 \pm 0.14 \mu\text{g C g}^{-1} \text{ h}^{-1}$ (using a $\beta = 0.14^\circ\text{C}^{-1}$) and for western hemlock $E_s = 0.95 \pm 0.17 \mu\text{g C g}^{-1} \text{ h}^{-1}$ (using a $\beta = 0.06^\circ\text{C}^{-1}$). Significant differences between the standard emission rates for each year were observed indicating some type of long term control of emission rates possibly related to variations in nutrient availability or larger scale ecological events. Overall there was no significant correlation between time of season, or location within the canopy and emission rates. In general, the Douglas fir data fit the temperature-emission algorithm better than the western hemlock data. Biogenic hydrocarbon branch enclosure measurements are also reported for a young managed poplar plantation. Emission samples collected at the managed poplar plantation were measured by subjecting the leaf to photosynthetic photon flux density (PPFD) levels of 1000 $\mu\text{mol m}^{-2} \text{ s}^{-1}$ and a temperature of 30°C. The average isoprene emission rate for the poplars was $E_s = 105.0 \pm 27.6 \mu\text{g}$

$\text{C g}^{-1} \text{ h}^{-1}$ on a mass basis and $E_s = 170.4 \pm 39.3 \mu\text{g C m}^{-2} \text{ s}^{-1}$ on a leaf area basis. The role of biogenic hydrocarbon emissions in terrestrial carbon exchange is quantified and compared for these two different ecosystems. On a leaf level basis, the average fraction of assimilated carbon emitted in the form of BHCs is relatively high (0.99%) for the poplar trees and much lower for the old growth conifers (0.2% for western hemlock and 0.06% for Douglas fir). Depending on the amount of light received and ambient temperatures western hemlock can emit rather high (up to 1.0%) amounts of fixed carbon. Emissions are also compared to physiological parameters such as PPFD, relative humidity, temperature, photosynthesis rates, and transpiration rates. The strongest correlation was between biogenic emissions and temperature as expected, although there was a large degree of scatter with the western hemlock data. The emission measurements reported here represent one of the first extensive datasets for an old growth forest. Very few studies are based on such a large number of enclosure samples from a limited number of species. Most enclosure studies involving a large dataset have also been conducted in controlled environments. Thus, emission inventory standard emission rates are typically based on limited emission samples from ambient conditions, or samples from seedlings in controlled environments. The emission rates presented in this thesis will contribute to improving the biogenic emission inventory factors used for future modeling.

Major Professor(s): Lamb, Brian K.
Department: Civil and Environmental Engineering
Principal Investigator(s): Lamb, Brian K.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON CYCLE, EMISSION, FOREST, HYDROCARBON, ORGANICS, TERRESTRIAL ENVIRONMENT, TREE

50

Pritchard, Seth. 1998. The Influence of Elevated Atmospheric Carbon Dioxide on Longleaf Pine Needles. *Ph.D. Thesis, Auburn University, 182 pages.*

The influence of rising atmospheric CO_2 on leaf structure and tissue quality of trees must be understood before it will be possible to predict the fate of trees, ecosystems, and entire biomes to atmospheric CO_2 levels predicted for the next century. Therefore, longleaf pine (*Pinus palustris* Mill.) seedlings were

grown for 20 months at two levels of CO_2 (365 and 720 mol mol^{-1}), in two levels of soil N (4 and 40 g m^{-2}), and with two levels of soil moisture (-0.5 and -1.5 MPa xylem pressure potential). Leaf tissue was collected 4, 8, 12 and 20 months after initiation of the experiment and prepared for light microscopy, scanning electron microscopy (SEM), and transmission electron microscopy (TEM). Needle phenolic content was determined using the Folin-Denis method, and condensed tannins were estimated with a protein precipitation Assay at the final (20 month) harvest. Although significant interactions of soil N with CO_2 were observed for leaf anatomy and morphology at the first harvest (4 months), few significant main effects or interactions of CO_2 , soil N or water levels were detected at later harvests. At the 12 month harvest, a CO_2 by N by water interaction was observed for the size of starch grains within chloroplasts. Disruption of chloroplast integrity by large starch inclusions was pronounced in needles from trees grown in elevated CO_2 when water and N were both limiting. At 20 months, chloroplasts grown in high CO_2 exhibited stress symptoms including increased numbers of plastoglobuli and shorter grana. Needle surface wax density was decreased and epicuticular wax morphology was altered by growth in elevated CO_2 only when soil N was limiting. Total leaf polyphenol and condensed tannin contents were increased by main effects of elevated CO_2 , low soil N and adequately watered conditions. Elevated CO_2 and low N decreased deposition of calcium oxalate crystals within needle phloem compared to ambient CO_2 and high N. Needle tissue quality, and thus interactions between pathogens/herbivores and longleaf pine, may be altered under elevated CO_2 . Furthermore, decreasing effects of elevated CO_2 on needle morphology and anatomy with increasing length of the study, coupled with negative effects of elevated CO_2 on ultrastructural characteristics of the photosynthetic apparatus suggest that some degree of photosynthetic acclimation may have occurred. Results from this study provide data useful in understanding how the longleaf pine ecosystem will respond to future CO_2 levels. Furthermore, they suggest that pine species may be inherently less able to exploit extra carbon in a high CO_2 world than broadleaf species.

Major Professor(s): Peterson, Curt M.
Department: Botany and Microbiology
Principal Investigator(s): Rogers, Hugo
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON DIOXIDE, CHLOROPLAST, FERTILIZATION, HERBIVORY, LEAF,

51

Pyles, R. David. 2000. The Development and Testing of the UCD Advanced Canopy-Atmosphere Soil Algorithm (ACASA) for Use in Climate Prediction and Field Studies. *Ph.D. Thesis, University of California Davis, 191 pages.*

The UCD Advanced Canopy-Atmosphere-Surface model is presented and its output is compared with a comprehensive set of observations at six diverse sites. ACAS is a multi-layer canopy-surface-layer model that solves the steady-state Reynolds averaged fluid flow equations to the third order. These equations include explicit representation of the full steady-state, horizontally homogeneous, diabatic set of vector and scalar fluxes and flux transports. ACAS includes a fourth-order, near-exact technique to calculate leaf, stem, and soil surface temperatures and surface energy fluxes at various levels within the canopy. Plant physiological response to micro-environmental conditions from a groomed grass field in the Netherlands, deciduous and coniferous forests in Canada, tropical pasture and forest in Brazil, and ancient temperate rainforest in the Pacific Northwest of the United States are compared with simulated values.

Major Professor(s): Paw U, Kyaw Tha, and Bryan C. Weare

Department: Land, Air, and Water Resources

Principal Investigator(s): Paw U, Kyaw Tha

Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CANOPY, ENERGY FLUX, MODEL

52

Qi, Ye. 1994. Human-Induced Biospheric Change and the Global Carbon Cycle: A Spatial Modeling Approach and its Application to Tropical Asia. *Ph.D. Dissertation, State University of New York at Syracuse, 250 pages.*

I have developed a computer model, called GEOMOD, to simulate land use change and its consequences on biotic carbon exchanges between terrestrial ecosystems and the atmosphere, using a spatial modeling approach. Land use change is a most important part of the anthropogenic disturbance to the terrestrial biosphere. Its contribution to the atmospheric carbon dioxide

accumulation is only second to fossil fuel combustion. Therefore modeling land use change has drawn great interest among the scientist community of global environmental change. Conventional models of land use change usually neglect the geographical heterogeneity within a region and thus cannot provide the spatial distribution of various land uses and their changes. We adopt a spatial modeling approach in this study. First, the input and output of the model are geographically-explicit. Spatial patterns of land use and factors that are related to land use change are represented with matrix-format raster data files. Each raster is dealt with independently; Secondly, the change of land use patterns are made driven by local features of geographical, ecological, and societal variables. I first tested my model by applying it to Peninsular Malaysia and Chiang Mai, Thailand, two relatively small areas in tropical Asia. I found that a satisfactory accuracy can be obtained for simulating the changes in land use patterns, when using only one initial land use pattern, topography, and land use change rates. This result suggests that land use pattern can be considered as a function of the initial pattern and topography in these cases. Then, I applied the model to thirteen countries in Tropical Asia, a much larger region than the test areas. In this application I made two model runs for comparison purpose. One is national level and the other sub-national. The national levels uses land use change rates for each country, while the sub-national run for each sub-national unit, or ecological zone. In addition, the spatial patterns of carbon content are also simulated. In chapter 4, I have developed a method, called normalized distance method, or RDM, for spatial pattern comparison and model validation. I analyzed the weakness of previous methods and construct a new index, normalized distance. The new index improves the previous methods by incorporating the locational information, as well as the number of matched gridcells. I analyzed the effects of changing spatial scales on spatial pattern analysis, by computing the responses of four spatial autocorrelation coefficients to varying grid sizes. I found that all spatial autocorrelation coefficients are scale dependent for the data sets I used. This result suggests that scale effects be carefully incorporated when interpreting the results of spatial modeling. The overall objective of the study is to explore the approaches and tools for studying land use change and its impacts on the global carbon cycle. However, we have found our results of model simulations could be used to feed three dimensional atmospheric transport models.

Major Professor(s): Hall, Charles A.S.

Department: Graduate Program in Environmental

Science

Principal Investigator(s): Hall, Charles A.S.
Program Area: Carbon, Climate, and Vegetation

KEYWORDS: CARBON CYCLE, MODEL, SPATIAL DISTRIBUTION, TERRESTRIAL ENVIRONMENT, TROPICS

53

Reimer, Paula J. 1998. Carbon Cycle Variations in a Pacific Northwest Lake During the Late Glacial to Early Holocene. *Ph.D. Dissertation, University of Washington, 188 pages.*

Carbon isotopes and elemental analysis of lake sediments and macrofossils from a Pacific Northwest lake are used to constrain climate and atmospheric ^{13}C changes since the Late Glacial. An increase of 1.6‰ in ^{13}C of bulk organic matter is seen at the transition to the Holocene. When corrected for mixing of terrestrial and lacustrine carbon based on the C:N ratio, the residual ^{13}C decreases by about 1‰ at the Late Glacial/Holocene transition, which probably reflects the change in atmospheric ^{13}C , and then rises to about 0.5‰ above the expected value as productivity increases drive the lacustrine ^{13}C upward.

Major Professor(s): Stuiver, Minze
Department: Geological Sciences
Principal Investigator(s): Stuiver, Minze
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON, CARBON CYCLE, CLIMATE, HOLOCENE, ICE AGE, ISOTOPE, LAKE, SEDIMENT

54

Remillard, Suzanne Marie. 1999. Soil Carbon and Nitrogen in Old-Growth Forest in Western Oregon and Washington. *M.S. Thesis, Oregon State University, 121 pages.*

Soil organic carbon (SOC, kg C m^{-2}) is an important component in evaluating global C stores. The nitrogen (TN, kg N m^{-2}) cycle is closely linked to C and understanding its role is also important. Contents and distributions of SOC and TN in soil profiles, to 1-meter depth, were estimated from 79 soils pits, in old-growth forests, in 7 physiographic provinces in western Oregon and Washington. Soils were sampled in four layers, forest floor, 0- to 20-cm, 20- to 50-cm, and 50- to 100-

cm, and analyzed on a LECO CN Analyzer. Material <2-mm was analyzed, as well as C-bearing material >2-mm. Forest floor SOC ranged from 0 to 14 kg C m^{-2} (mean = 2.7) and forest floor TN ranged from 0 to 0.4 kg N m^{-2} (mean = 0.07). The SOC of mineral soil ranged from 1.0 to 18 kg C m^{-2} (mean = 6.6) for 0- to 20-cm depth and 2.2 to 57 kg C m^{-2} (mean = 17) for 0- to 100-cm depth. The TN of mineral soil ranged from 0.04 to 1.0 kg N m^{-2} (mean = 0.31) for 0- to 20-cm depth and 0.12 to 3 kg N m^{-2} (mean = 1.0) for 0- to 100-cm depth. Up to 66% of SOC and TN measured was found below 20-cm, illustrating how failing to sample at depth can grossly underestimate SOC. As much as 44% of SOC and TN measured was found in C-bearing material >2-mm, material for which many methods neglect to account. Longitudinal differences in SOC and TN contents were evident between Coastal, Cascade, and Eastside Cascade sites, implying effects from site and climatic factors. Regression analysis was used to quantify relationships of SOC and TN to site and climatic factors. Response variables included forest floor, forest floor plus 0- to 20-cm, 0- to 20-cm, and 0- to 100-cm layers. Moisture and soil texture played important roles in most cases examined. The results of this study, and of other studies assessing the effects of site and climatic characteristics on the factors controlling soil organic matter accumulation, suggest the relationships are regionally specific.

Major Professor(s): Homann, Peter S., and Bernard T. Bormann
Department: Forest Science
Principal Investigator(s): Harmon, Mark E.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON, CARBON CYCLE, CLIMATE, FOREST, NITROGEN CYCLE, ORGANICS, SOIL, SPATIAL DISTRIBUTION

55

Riemer, Daniel D. 1998. Marine and Terrestrial Sources of Reactive Volatile Organic Compounds and Their Impact on the Tropospheric Ozone Chemistry of the Earth. *Ph.D. Dissertation, University of Miami, 187 pages.*

Two areas integral to the global cycle of tropospheric ozone were studied. The first segment of this investigation involved the study of marine ecosystems to define the sources of nonmethane hydrocarbons (NMHCs) in the surface ocean. This included

laboratory and field investigations conducted to determine the function and importance of dissolved organic matter (DOM) in the abiotic photochemical production of nonmethane hydrocarbons in surface seawater. Concurrently, phytoplankton were investigated as a biogenic sources of NMHCs in the surface ocean. Low molecular weight alkenes, compounds observed in the greatest concentrations in the surface ocean, are formed almost exclusively as a result of DOM-mediated photochemistry. Isoprene was found to be produced by all phytoplankton species investigated. The primary sink for NMHCs found in surface seawater was gas exchange. The second segment of this study focused on the prevalence of NMHCs and oxygenated volatile organic compounds in the rural southeastern United States. (Note: Research supported also by the Office of Naval Research and the Environmental Protection Agency)

Major Professor(s): Zika, Rod G.
Department: Marine and Atmospheric Chemistry
Principal Investigator(s): Milne, Peter J.
Program Area: Atmospheric Chemistry

KEYWORDS: *ATMOSPHERE, EMISSION, HYDROCARBON, OCEAN, ORGANICS, OZONE, PLANKTON, TROPOSPHERE*

56

Saros, Misa. 1995. Sensitivity of Pulse Heights to Pressure for Ultrafine Particles in the Ultrafine Condensation Particle Counter (UCPC). *M.S. Thesis, University of Minnesota Twin Cities, 71 pages.*

Previous work has shown that for particles smaller than about 15 nm in diameter there is a dependence of pulse heights produced by the optical detector in an ultrafine condensation particle counter (UCPC) on initial particle size. Using this technique with the UCPC described by Stolzenburg and McMurry (1991) valuable information has been obtained about size distributions and concentrations of atmospheric particles in the 3 to 4 nm diameter range. In future work this technique will be used with aircraft measurements; information on the dependence of pulse heights on pressure in the 0.25 to 1.0 atm range will be required to interpret this data. This thesis describes a laboratory study of the sensitivity of UCPC pulse heights to pressure. Possibilities for improvement of the pulse height analysis technique are also discussed. Monodisperse sodium chloride (NaCl) or ammonium sulfate ((NH₄)₂SO₄) particles in the 3 to 12 nm diameter range

were delivered to the UCPC which was operated at pressures ranging from 0.25 to 1 atm. The calibration aerosols were generated by rapidly cooling a hot vapor to induce nucleation of ultrafine particles followed by a differential mobility analyzer (DMA) to select particles of known size. A short DMA (classifier length = 10.5 cm) was used to minimize diffusional broadening. A calibration of the UCPC optics was also performed using monodisperse oleic acid particles (between 5 and 15 μm in diameter) from a vibrating orifice aerosol generator (VOAG). The results of the experiments demonstrate that pulse heights increase for particles of all sizes as the pressure drops from 1 atm to about 0.6 atm. Below 0.6 atm, pulse heights decrease monotonically with pressure. At a pressure of 0.25 atm, pulse heights are reduced by more than 50% relative to those at 1 atm. While the absolute pulse heights change with pressure, the relative spacing of the pulse height distribution does not. That is, the pulse height difference between two particles of different sizes remains nearly constant over the pressure range in question. While the pulse height difference is insensitive to pressure, it does depend on particle composition. Indeed, the pulse height difference was consistently greater for NaCl particles than for (NH₄)₂SO₄ particles. It seems likely that this is a result of particle shape and not of chemical composition. Nonetheless, it is clear that care must be taken to calibrate with aerosols that are representative of those being measured. Finally, these experimental results are also compared with the predictions of a particle growth model developed by Stolzenburg. While there is qualitative agreement between the model and experimental results, modifications to the model will be required if quantitative accuracy is to be achieved.

Major Professor(s): McMurry, Peter H.
Department: Mechanical Engineering
Principal Investigator(s): McMurry, Peter H.
Program Area: Atmospheric Chemistry

KEYWORDS: *AEROSOL, CONDENSATION, GASES, NUCLEATION, PARTICULATE*

57

Schoof, Justin T. 1999. Synoptic Circulation Classification and Downscaling for the Midwestern United States. *M.S. Thesis, Indiana University, 174 pages.*

This thesis is the culmination of a synoptic circulation classification for the Midwestern United States and the

application of the derived circulation indices in a downscaling methodology for surface air temperature and precipitation. The variables used in the classification are twice daily observations of: 500mb and 700mb height, 850mb temperature, and 850mb dew point temperature, plus a single derived value; precipitable water content (from the surface to 500mb level). These data are used to develop the synoptic circulation classification for the growing and non-growing seasons (defined based on surface temperature) and are taken from 7 radiosonde sites within the study area for the period 1971-1990. The classifications are undertaken using Varimax orthogonally rotated principal components analysis and validated by comparison with obliquely rotated components and using hierarchical cluster analysis of the component scores. Half of the randomly chosen component scores from the 5 significant growing and non-growing season components are then used to construct feed-forward backpropagation neural networks to predict surface temperature and precipitation at Indianapolis, IN. The neural networks are then tested using the remainder of the classification data set. The results are discussed in terms of prediction accuracy and compared to a downscaling methodology based solely on multiple regression analysis.

Major Professor(s): Pryor, Sara C.
Department: Geography
Principal Investigator(s): Pryor, Sara C., Rebecca J. Barthelmie, Margaret Carreiro, C. Susan Grimmond, and Hans P. Schmid
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ATMOSPHERE, CIRCULATION, CLIMATE, NEURAL NETWORK, PRECIPITATION, SPATIAL DISTRIBUTION, SURFACE LAYER, TEMPORAL DISTRIBUTION

58

Sea, William B. 1999. Measures of spatial variability in turbulent fluxes of carbon dioxide and water vapor at the WLEF site during summer 1997. *M.S. Thesis, University of Minnesota, 35 pages.*

Fluxes from three levels on the WLEF tower were subdivided into wind sectors and analyzed to detect significant differences in flux as a function of wind direction. It was established with summer 1997 data that midday CO₂ uptake did vary with wind direction. Wind sectors were divided into upland and lowland

fractions and compared to the flux data. No significant correlation between this simple footprint model and the observed flux variability was found. Water vapor fluxes from the same period were modeled using the Penman-Monteith equation. Good agreement was found. Discrepancies were related to the time since last rainfall.

Major Professor(s): Davis, Kenneth J.
Department: Water Resources Science
Principal Investigator(s): Bakwin, Peter S.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON CYCLE, FLUX, MODEL, SPATIAL DISTRIBUTION, WATER VAPOR, WIND

59

Shen, Jinmei. 1996. Interactions Between Land Surface and the Atmosphere and the Role of GCM Sub-Grid Heterogeneity. *M.S. Thesis, Iowa State University, 102 pages.*

This thesis consists of two papers to be submitted for publication: 1) Comparison of the influences of land surface properties on mesoscale circulations using two land surface process schemes. 2) The influence of surface heterogeneity on subgrid heat fluxes and boundary layer turbulence structure. In the first paper, comparison is made between two surface parameterization schemes: the Simple Biosphere Model SiB2 of Sellers and the Biosphere Atmosphere Transfer Scheme (BATS) of Dickinson, et al. Sensitivity analyses are carried out on soil and vegetation parameters by comparison with observations from three locations. The second paper examines the effects of subgrid heterogeneity on surface fluxes and mesoscale circulations. A series of sensitivity simulations demonstrates the role of GCM subgrid heterogeneity.

Major Professor(s): Arritt, R.W., and E.S. Takle
Department: Geological and Atmospheric Sciences
Principal Investigator(s): Brandle, J.R., W.E. Easterling, and E.S. Takle
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: BOUNDARY LAYER, CIRCULATION, FLUX, HEAT, LAND SURFACE, MODEL, SOIL, SPATIAL DISTRIBUTION, TURBULENCE, VEGETATION

Shipham, Mark. 1997. An Analysis of High Frequency Methane Measurements in Central New England. *Ph.D. Thesis, University of New Hampshire, 76 pages.*

A unique high resolution ambient air methane data set consisting of approximately 125,000 independently measured data points for the years 1991-1995 has been collected at a site in the northeastern United States. This data base is used to examine the long term trend, seasonal and diurnal cycles, and the frequent pollution events that affect the site on a year round basis. The annual median mixing ratio of methane for all measurements was 1808 ppbv in 1992, increasing at a variable rate to 1837 ppbv in 1995. The lower 10-30% of the data from each month was defined as representative of background air and was compared to the global CMDL data set. The background data exhibit a variable upward trend of 5.5 ± 2 ppbv/year during the 4-year time period, with most of the increase observed during 1993 and 1994. The seasonal cycle for the background data set is similar to what is observed by CMDL stations and varies from 24 to 35 ppbv. The amplitude of the seasonal cycle for the full data set was larger, ranging from 35 to 44 ppbv. Differences between the full and background mixing ratios vary on a seasonal basis and are largest in the winter and smallest in the summer. These differences appear to be controlled by changes in atmospheric stability and changes in emissions from local and regional sources throughout the year. Wind roses of chemical species are examined for annual and seasonal time periods with enhancements in anthropogenic species corresponding to the location of large cities and landfills. Methane is strongly correlated to species that have an anthropogenic component, including acetylene, propane, ethane, and hexane. The southwest quadrant is subjected to the most severe pollution events and is impacted by outflow from large cities in that sector, including Northampton and Springfield, MA. Emissions from cities in other quadrants, including Boston and Worcester, MA, Providence, RI, and the near by town of Petersham, MA also affect the site, but to a lesser degree. Case studies are used to identify atmospheric conditions that lead to high concentrations of methane and other species. The co-occurrence of a persistent wind direction, light wind speed, and stable atmospheric conditions is the ideal scenario in which emissions from nearby cities and landfills are advected to the site. Emissions from local and regional, rather than distant sources, are the primary cause of elevated events.

Major Professor(s): Harriss, Robert, and Patrick Crill
Department: Earth Sciences
Principal Investigator(s): Crill, Patrick
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ATMOSPHERE, EMISSION, METHANE, SPATIAL DISTRIBUTION, TEMPORAL DISTRIBUTION

61

Siqueira, Andrea. 1997. The Ecology of Food and Nutrition: Patterns of Land Use and Nutritional Status Among Caboclo Populations on Marajó Island, Pará, Brazil. *Ph.D. Dissertation, Indiana University, 402 pages.*

During the past 30 years, the magnitude of environmental, economic and political change taking place in Amazonia have had profound impact on the social, economic, nutritional and health status of native populations. Caboclos, the native Amazon peasant, practice an economy based on multiple resource use, including agriculture, fishing, hunting, management and extraction of forest products. These activities of subsistence and economy have been directly and/or indirectly affected by the changes taking place in the region as a whole. Some of these effects can be observed in changes in land use and in the strategies of subsistence and economy of these rural populations. Others, however, need to be understood at the level of social organization and biological adaptation of these populations. This study investigates the relationships between land use and nutritional status among Caboclo populations on Marajó Island, Pará, Brazil. Different land use and patterns of subsistence and economy are compared. Nutritional status is assessed through food intake surveys and anthropometric measurements of physical growth and development. Changes in land use are assessed through ethnographic research and data from remote sensing analysis. The study presents and discusses qualitative and quantitative data collected in different field seasons between 1989 and 1994. The results show that indeed land use changes affect food availability and security at the household and population levels. Overall, however, the study populations present signs of chronic malnutrition. Food with high energetic content is seasonally available. In addition, sanitary conditions and health services are also limited. Interestingly enough, the incidence of malnutrition is not biased towards any specific category, such as gender, age group or landownership.

Nevertheless, factors such as social organization, land tenure and household decision-making processes are important dimensions to understand land use and nutritional status variations among and within populations.

Major Professor(s): Moran, Emilio F.
Department: Anthropology
Principal Investigator(s): Moran, Emilio F.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ESTUARY, GROWTH AND DEVELOPMENT, HEALTH, TROPICS

62

Tian, Hanqin. 1996. Metabolism of the Biosphere in Changing Global Environments: Carbon Flux and Land Use Change as Studied at Scales From Landscape to Global. *Ph.D. Dissertation, State University of New York at Syracuse, 240 pages.*

The basic pattern of the metabolism of the biosphere appears to be changing, based on my analysis of monthly records since the 1950's of atmospheric CO₂ concentration, fossil fuel consumption, and oceanic absorption of carbon dioxide. The changes determined by my method include a significant increase in both production and respiration of the biosphere since the 1970's. Nevertheless, the ratio of production and respiration (P/R) remains a constant 1.0 during the past 35 year period. Terrestrial ecosystems in the middle and high latitudes of the northern hemisphere appear to be more sensitive in their response to changing global environments than other areas as shown by the rate of metabolism change. I developed a simple metabolism model to conduct simulation experiments and uncertainty analysis about what possible changes in ecosystem function might lead to the observed changes in atmospheric CO₂. I also investigated the role of changing land use in the changes of global metabolism through two case studies in tropical and boreal Asia. My study in boreal Asia shows that many of these ecosystems are in early successional changes due to their recovery from deforestation. The high rate of metabolism in early successional stages may be one of the important factors that has enhanced the metabolism of the biosphere. My study in South and Southeast Asia shows an increase in agricultural area and a decrease in carbon storage. Specially, I applied a spatially-explicit model of land use change, called GEOMOD, to quantify spatial and temporal patterns of land use

change in South and Southeast Asia. The expansion of agricultural land into forested land may be the cause of the increase in seasonal amplitude of atmospheric CO₂ if the annual net production of crops is greater than the annual net production of forests.

Major Professor(s): Hall, Charles A.S.
Department: Department of Environmental Forest and Biology
Principal Investigator(s): Hall, Charles A.S.
Program Area: Carbon, Climate, and Vegetation

KEYWORDS: BOREAL REGION, CARBON CYCLE, LAND SURFACE, LAND USE, METABOLISM, MODEL, NORTHERN HEMISPHERE, SPATIAL DISTRIBUTION, TERRESTRIAL ENVIRONMENT, TROPICS

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Vanyarkho, Olga V. 1996. Seasonal changes in vegetative characteristics and gas exchange properties of *Phragmites australis* and *Scirpus acutus* in a mid-latitude prairie wetland ecosystem. *M.S. Thesis, University of Nebraska at Lincoln, 75 pages.*

Our research was conducted in the Sandhills region of Nebraska as a part of a comprehensive field experiment on trace gas and energy fluxes in mid-latitude wetland ecosystems. Field measurements were conducted from April to October, 1994 at Ballards Marsh and Dewey Lake Fen near Valentine, Nebraska. We measured single leaf physiological properties and water surface CO₂ fluxes using a portable gas exchange system. Total canopy foliage index, biomass accumulation, and related vegetative parameters were determined by destructive sampling. *Phragmites australis* and *Scirpus acutus*, dominant plant community types for these wetlands, had similar seasonal trends in canopy heights, biomass accumulation, and leaf area index at both sites. However, the Dewey Lake Fen communities had taller canopies and greater biomass and leaf area indices. At Ballards Marsh, both species exhibited similar seasonal patterns of single leaf CO₂ assimilation and stomatal conductance. Assimilation rates for *Phragmites* under full sunlight in mid-July were higher (20-22 μmol m⁻² s⁻¹) than for *Scirpus* (17-20 μmol m⁻² s⁻¹). Stomatal conductance was higher for *Scirpus* (0.5-0.6 mol H₂O m⁻² s⁻¹) than for *Phragmites* (0.3-0.4 mol H₂O m⁻² s⁻¹), which was, probably due to higher internal CO₂ concentration in *Scirpus* than in *Phragmites*. Surface CO₂ fluxes reached a maximum in the beginning of August (*Phragmites*-dominated areas:

2.95 $\mu\text{mol m}^{-2} \text{s}^{-1}$, *Scirpus*-dominated areas: 2.05 $\mu\text{mol m}^{-2} \text{s}^{-1}$). The total canopy foliage indices reaches maximum values by the beginning of August. We used a simple radiative transfer model (Norman 1992) to scale up net CO_2 assimilation and conductance from leaf to canopy level for selected days. In general, canopy net CO_2 assimilation for *Phragmites* was higher (16-17 $\mu\text{mol m}^{-2} \text{s}^{-1}$) than for *Scirpus* (12-13 $\mu\text{mol m}^{-2} \text{s}^{-1}$); however, canopy conductance was higher in *Scirpus* than in *Phragmites* (0.6 $\text{mol H}_2\text{O m}^{-2} \text{s}^{-1}$ versus 0.5 $\text{mol H}_2\text{O m}^{-2} \text{s}^{-1}$). The magnitude of these differences was related to the proportion of incident radiation that was direct beam.

Major Professor(s): Arkebauer, Timothy J.
Department: Agronomy
Principal Investigator(s): Verma, Shashi B.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: BIOMASS, CARBON CYCLE, FLOW, GASES, LEAF, MODEL, PRAIRIE, STOMATE, TEMPORAL DISTRIBUTION, VEGETATION, WATER, WETLAND

64

Venkatesh, Ramasubbu. 1995. A Classical Trajectory Study of Collisions of 2-15 Atom Nickel Clusters. *Ph.D. Dissertation, Texas A&M University, 158 pages.*

The collisions of 2 - 15 atom nickel clusters have been studied using the classical trajectory method. Three cases were considered: cluster-monomer, cluster-dimer and cluster-cluster collisions. The interaction between the nickel atoms is modeled using a semi-empirical many-body potential based on the second moment approximation of the tight-binding scheme. The cross section results obtained in this study are consistent with the smooth and featureless distributions observed for nickel and other transition metal clusters. The two major assumptions made in cluster growth model, the substitution of cluster formation rate by hard sphere collision rate and the estimation of decay rate by assuming exponential decay of collisionally formed clusters, were examined and found to be reasonable assumptions. The results pertaining to the study of cluster decay however suggest that in addition to the decay rate dependence on energy, its angular momentum dependence should also be taken into account in cluster decay rate calculations. The cluster-monomer and cluster-cluster collisions were also studied using bulk and dimer fitted Lennard-Jones

potentials. A comparison of the cross section results for these two potentials with those obtained using the many-body potential suggest that the rate calculations may be sensitive to the nature and Parameterization of the interaction potential depending on the temperature considered and cluster growth process simulated. This work has systematically addressed the basic issues related to cluster growth modeling for a material of technological interest.

Major Professor(s): Marlow, William H.
Department: Nuclear Engineering Department
Principal Investigator(s): Marlow, William H.
Program Area: Atmospheric Chemistry

KEYWORDS: METAL, MODEL, MOMENTUM

65

Voss, Michael. 1996. Estimating Global Monthly Mean Vertical Cloud Amount: Method and Result. *M.S. Thesis, University of California at Davis, 77 pages.*

Existing cloud climatologies fail to provide information regarding the vertical extent of clouds. A methodology is developed whereby a global vertical cloud climatology is created. Cloud bulk microphysical properties are estimated and combined with satellite derived optical depth to determine cloud thickness. Monthly mean cloud amounts from the International Satellite Cloud Climatology Project (ISCCP) are then assembled with cloud thickness distributions to produce a three dimensional cloud climatology. The resulting monthly mean vertical cloud climatology provides height specific cloud amount between 60°N and 60°S. The methodology employed does introduce large systematic uncertainties which are difficult to assess. Nonetheless, the results are compared with the Atmospheric General Circulation Model (AGCM) simulated cloud amount revealing large discrepancies in both the magnitude and relative spatial distribution of cloud amount. The elevation of maximum cloud amount is significantly higher in the AGCM's than found in this research.

Major Professor(s): Weare, Bryan C.
Department: Land, Air and Water Resources
Principal Investigator(s): Weare, Bryan C.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CLIMATE, CLOUDS, MODEL

Wang, Xianzhong. 1999. Gender-specific and intraspecific response of trembling aspen (*Populus tremuloides*) to elevated atmospheric carbon dioxide. *Ph.D. Thesis, Ohio State University, 129 pages.*

I studied gender-specific and intraspecific variations in the physiological responses of *Populus tremuloides* to elevated CO₂ as affected by soil N availability. I also synthesized leaf dark respiration data from independent studies using meta-analysis. Net CO₂ assimilation rate (A) of male *P. tremuloides* was 17.8 and 26.2 micro mol m⁻² s⁻¹ at ambient and elevated CO₂, significantly higher than A of females of 15.6 and 21.0 micro mol m⁻² s⁻¹. Male trembling aspen had a higher maximum rate of CO₂ fixation by Rubisco and area-based leaf dark respiration (R_{da}). Mass-based leaf Rd (R_{dm}), however, was unaffected by gender and CO₂ concentration, although the results of meta-analysis on 44 independent observations showed that R_{dm} was reduced 18.4% by elevated CO₂. We found a positive correlation between R_{da} and leaf starch content, which was higher at elevated CO₂, but no correlation between R_{da} and leaf N content was observed, suggesting the importance of starch content in determining the magnitude of respiration. Total biomass accumulation of female *P. tremuloides* was higher than that of males in low-N soil and at ambient CO₂, but not in other treatments. Elevated CO₂, on the other hand, significantly increased total biomass of both male and female trees in low- and high-N soil, with the increase ranging from 22-70% for female and 58-66% for male trees. There was a significant CO₂ x genotype interaction in photosynthetic responses to CO₂ enrichment, wherein A was significantly enhanced by elevated CO₂ for five genotypes in high-N soil and for four genotypes in low-N soil. Enhancement of A by elevated CO₂ ranged from 14% to 68%. We found a correlation between the degree of A enhancement to elevated CO₂ and stomatal sensitivity to CO₂. Stomatal conductance and A of different genotypes also responded differentially to drought stress. Our results suggest that *P. tremuloides* genotypes and genders respond differentially in A and Rd to rising atmospheric CO₂, with the degree of responses dependent upon other environmental factors. These differential responses will likely alter the distribution and population structure of this ecologically important species in a CO₂ enriched environment.

Major Professor(s): Curtis, Peter S.
Department: Environmental Science
Principal Investigator(s): Teeri, James A.

Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON DIOXIDE, GENETICS, PHOTOSYNTHESIS, RESPIRATION, TREE

Wang, Xiaoli. 1997. Global Thermohaline Circulation and Ocean-Atmosphere Coupling. *Ph.D. Thesis, Massachusetts Institute of Technology, 134 pages.*

A global ocean general circulation model of idealized geometry, combined with an atmospheric model based on observed transports of heat, momentum, and moisture, is used to explore the sensitivity of the global conveyor belt circulation to the surface freshwater fluxes, in particular, the effects of meridional atmospheric moisture transports. The numerical results indicate that the equilibrium strength of the North Atlantic Deep Water (NADW) formation increases as the global freshwater transports increase. However, the global deep water formation, i.e., the sum of the NADW and the Southern Ocean Deep Water formation rates, is relatively insensitive to changes of the freshwater flux. Perturbations to the meridional moisture transports of each hemisphere identify equatorially asymmetric effects of the freshwater fluxes. The equilibrium NADW formation is primarily controlled by the magnitude of the Southern Hemisphere freshwater flux. The Northern Hemisphere freshwater flux only has a significant impact on the transient behavior of the North Atlantic overturning. Increasing this flux leads to a collapse of the conveyor belt circulation, but the collapse is delayed if the Southern Hemisphere flux also increases. The perturbation experiments also illustrate that the rapidity of the collapse is affected by random fluctuations in the wind stress field. The atmospheric component of the coupled ocean-atmosphere model is modified to investigate the stability of the thermohaline circulation (THC) to an increase in the surface freshwater forcing in the presence of interactive meridional transports in the atmosphere. The atmospheric model still assumes a fixed latitudinal structure for the heat and moisture transports, but the amplitudes are now calculated separately for each hemisphere from the large scale sea surface temperature (SST) and SST gradient, using parameterizations based on baroclinic stability theory. The ocean-atmosphere heat and freshwater exchanges then are calculated as residuals of the steady-state atmospheric budgets. Owing to the ocean component's weak heat transport, the model has too strong a

meridional SST gradient when driven with observed atmospheric meridional transports. When the latter are made interactive, the conveyor belt circulation collapses. A flux adjustment is introduced in which the efficiency of the atmospheric transports is lowered, to match the too low efficiency of the ocean component. The feedbacks between the THC and both the atmospheric heat and moisture transports are positive, whether atmospheric transports are interactive in the Northern Hemisphere, the Southern Hemisphere, or both. However, the feedbacks operate differently in the Northern and Southern Hemispheres, because the THC upwells and causes equatorward heat transport in the latter. The feedbacks in the two hemispheres do not necessarily reinforce each other because they have opposite effects on low-latitude temperatures. The model is qualitatively similar in stability to one with conventional "additive" flux adjustment, but quantitatively more stable.

Major Professor(s): Stone, Peter H.
Department: Earth, Atmospheric and Planetary Sciences
Principal Investigator(s): Stone, Peter H.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: ATMOSPHERE, CIRCULATION, CLIMATE, MODEL, OCEAN

68

Weber, Rodney. 1995. Studies of New Particle Formation in the Remote Troposphere. *Ph.D. Dissertation, University of Minnesota Twin Cities, 183 pages.*

Particle formation and growth play key roles in determining the size distribution of remote tropospheric aerosols. Since these aerosols can have significant global climatic influences, understanding such processes is critical for accurate predictions of future climate. In this research, a method for measuring ultrafine particle concentrations (~3-4 nm diameter) was developed and applied to studies of tropospheric particle formation. Laboratory experiments showed that ultrafine condensation particle counter photo detector pulse heights provide a robust and sensitive measurement of ultrafine particle concentrations. Pulse heights were insensitive to particle size and composition, and were affected by the presence of large particles (diameters > 15 nm) only when concentrations were larger than $\sim 4 \times 10^3 \text{ cm}^{-3}$. Tropospheric

measurements were made at a remote marine (Mauna Loa Observatory, HI) and continental site (Idaho Hill, CO). At both sites, ultrafine particles were frequently detected and appeared to be from recent nucleation. Measurements show that sulfuric acid (H_2SO_4) was likely a primary precursor vapor whereas water (H_2O) was not. Preexisting aerosol surface area limited ultrafine concentrations by limiting the H_2SO_4 concentration and by scavenging newly formed particles. At both sites, measured 3 nm particle formation rates were much higher than nucleation rates predicted by classical H_2SO_4 - H_2O theory and were observed at much lower H_2SO_4 concentrations (10^5 - 10^7 cm^{-3}) than predicted by this theory (10^8 - 10^9 cm^{-3}). Furthermore, while binary theory predicts nucleation rates vary as $\sim [\text{H}_2\text{SO}_4]^{10}$, the measured particle formation rates varied as $[\text{H}_2\text{SO}_4]^2$, suggesting that kinetically, nucleation is H_2SO_4 collision limited. These discrepancies may result from additional species, such as ammonia (NH_3), participating in nucleation. A simple new (collision limited) H_2SO_4 - NH_3 - H_2O nucleation model is proposed. At both sites, the median particle diameter growth rate was 0.1 nm h^{-1} , calculated by assuming condensation of only hydrated H_2SO_4 vapor. Measurements indicate that growth rates were actually higher by factors of 1.5-2 at Mauna Loa and 5-10 at Idaho Hill. Higher growth rates may be from coagulation of molecular clusters with ultrafine particles, or condensation of additional species such as secondary organics.

Major Professor(s): McMurry, Peter H.
Department: Mechanical Engineering
Principal Investigator(s): McMurry, Peter H.
Program Area: Atmospheric Chemistry

KEYWORDS: AEROSOL, CONDENSATION, GASES, NUCLEATION, PARTICULATE

69

Winterson, Kristin. 1999. Carbon Sinks in Vegetation of the Southern Appalachian Mountains. *M.S. Thesis, University of Virginia, 80 pages.*

Forest Service data were analyzed for counties in the Southern Appalachian Region of Tennessee, North Carolina, Georgia, and Kentucky. Utilization of the diameter at breast height (DBH) measurements showed carbon sinks to exist in all counties. North Carolina and Georgia averaged 264 and $275 \text{ g C m}^{-2}\text{y}^{-1}$, respectively while Tennessee and Kentucky sequestered 161 and $80 \text{ g C m}^{-2}\text{y}^{-1}$. Analyses of varying allometric

equations proved inconsequential; all equations, when used for the entire region, passed an ANOVA test with $\alpha = 0.05$. Variations in carbon sequestration were most pronounced across state boundaries. Variations in stand age, human populations, and survey techniques are the most likely reasons for this observation. Eddy covariance data from Walker Branch Watershed, Harvard Forest, and boreal regions in Canada were comparable to the FIA results. To insure this region is a sink in the future, continued use of DBH measurements from the FIA data set should be utilized. Furthermore, data should be corroborated with atmospheric tower data wherever possible to test for accuracy.

Major Professor(s): Emanuel, William R.
Department: Environmental Sciences
Principal Investigator(s): Emanuel, William R.
Program Area: National Institute for Global Environmental Change (NIGEC)

KEYWORDS: CARBON, CARBON CYCLE, FOREST, SPATIAL DISTRIBUTION

70

Yu, Shaocai. 1996. The Spatial, Temporal, and Seasonal Variations of Climatological Variables, and the Impact of Stratospheric Volcanic Aerosols on Radiative Forcing in the Southeastern U.S. *M.S. Thesis, North Carolina State University, 109 pages.*

SECTION I. The monthly and yearly climatic data on the duration of growing season, mean, maximum, minimum and daily temperatures, diurnal temperature range (DTR), and precipitation in 52 stations over the Southeast US were statistically analyzed by SAS model during the period of 1949 to 1994 (46-year interval). The results showed that the growing season became longer in 61.5% of stations, and significantly longer in 13.5% of stations at the 0.05 level in the past 46 years. The arithmetic average of duration of growing season for 52 stations became longer by 1.7 days in past 46 years. The earlier start and later end of growing season led to the dominant longer duration of growing season in the Southeastern US. The annual mean daily temperature decreased in 51.9% of stations, and decreased significantly in 13.5% of stations at the 0.05 level in the past 46 years. The arithmetic average of annual mean daily temperature for 52 stations decreased by -0.09°C in the past 46 years. There were slightly cooling trends in the Southeastern US in the past 46 years. The annual total precipitation increased in 82.7% of stations, and there was dominant

increasing trend of total precipitation in all seasons except Summer in past 46 years. The annual total precipitation increased significantly in 9.6% of stations at the 0.05 level. The arithmetic average of annual total precipitation for 52 stations increased by 81 mm in the past 46 years. The annual, winter and summer mean maximum temperatures decreased in 67.0%, 90.4% and 63.5% of stations in the Southeastern US in the past 46 years, respectively. The annual mean maximum temperature decreased significantly in 15.4% of stations at the 0.05 level. The arithmetic average of annual mean maximum temperature for the 52 stations decreased by -0.28°C in the past 46 years. For mean minimum temperature, the annual, summer and fall mean values showed increasing trends in 59.1%, 69.2% and 82.7% of stations, respectively. The annual mean minimum temperature increased significantly in 19.2% of the stations at the 0.05 level. The arithmetic average of annual mean minimum temperature for the 52 stations increased by 0.09°C in the past 46 years. The annual, winter, summer and fall mean temperature range (DTR) became smaller in 69.2%, 67.3%, 76.9% and 75.0% of the stations, respectively. The annual mean DTR decreased significantly in 28.9% of the stations at the 0.05 level. The arithmetic average of annual mean diurnal temperature range for the 52 stations became shorter by -0.37°C in the past 46 years.

SECTION II. Major explosive volcanic eruptions inject massive amounts of dust and gases into the lower stratosphere and upper troposphere. Stratospheric volcanic aerosols can influence the radiation balance of Earth by scattering and absorbing radiation. Volcanic aerosols can scatter incoming solar radiation to space, increasing planetary albedo, reducing the total amount of solar energy reaching the troposphere and the earth's surface, decreasing the daytime maximum temperature (aerosol shortwave forcing). They can also absorb and scatter terrestrial longwave radiation, warming the nighttime minimum temperature (longwave forcing). Downward longwave radiation from the warming stratosphere also acts to warm the surface. However, persuasive evidence of climate response to this forcing has thus far been lacking. Here we examine patterns of annual and seasonal variations in mean maximum and minimum temperature trends over the two periods 1992-94 and 1985-87 relative to that over the period 1988-90 at 47 stations in Southeastern US for evidence of such climate responses. The stratospheric volcanic aerosol microphysical characteristics over the Southeastern US during the period 1985-1994 were inferred from the Stratospheric Aerosol and Gases Experiment (SAGE) II satellite extinction measurement using a modified randomized minimization search technique (RMST). The dominant decreasing trends of

mean maximum temperature and the dominant increasing trends of mean minimum temperature over period 1992-94 and 1985-87 relative to that over the period 1988-90 are consistent with the distribution of stratospheric volcanic aerosol and model calculation of aerosol forcing in the Southeastern US. The stratospheric volcanic aerosol forcing also has an effect on daily temperature, diurnal temperature range and precipitation in Southeastern US.

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Principal Investigator(s): Saxena, Vinod K.
Program Area: National Institute for Global
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*KEYWORDS: AEROSOL, CLIMATE, RADIATIVE
PROCESS, SPATIAL DISTRIBUTION, TEMPORAL
DISTRIBUTION, VOLCANO*