ENVIRONMENTAL MONITORING, EVALUATION, AND PROTECTION: LINKING SCIENCE AND POLICY

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POSTER ABSTRACTS

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25 YEARS OF ATMOSPHERIC MONITORING AT WHITEFACE MOUNTAIN OBSERVATORY: A DATA SET AVAILABLE FOR THE ENVIRONMENTAL RESEARCH COMMUNITY

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Long-term records of trace gas (O_3, NO, NO_2, NO_Y, SO_2, CO) atmospheric constituents and standard meteorological parameters have been collected at the Whiteface Mountain Observatory in the Adirondack Mountains of northern New York. Built in 1971 by the Atmospheric Sciences Research Center (ASRC) of the University of Albany, the observatory sits atop Whiteface Mountain (44.366°N 73.903°W) at 1483 m above sea level. At this altitude, near the 850 mb pressure level, the bulk of the trace gases arrive from long-range transport from regional sources.

Analysis of the record has shown that local pollution rarely contaminates the summit sampling site[a].

Tropospheric ozone has been continuously monitored since 1973, with CO and oxides of nitrogen added to the monitoring program in 1988 followed by SO_2 in 1992. Beginning in 1989, trace gas and meteorological data were collected electronically at one-minute intervals, then processed and stored as hourly averages. This data set will span a 25-year period at the end of 2013, and will be openly available to the research community for the period 1989 – 2011, with the most recent data added after processing and quality control. Three of these records—SO_2, temperature, and O_3—are shown here as examples of trends over the period of record. The remarkable decrease of SO_2 from an annual average of more than 1.2 ppbv to under 0.2 ppbv demonstrates the effectiveness of implemented regulatory emission control actions. It also demonstrates the challenges faced by modern instrumentation as it attempts to detect ever decreasing trace levels of atmospheric pollutants at this location.

A second instrumented site is located on the shoulder of Whiteface Mountain near ASRC's Marble Mountain Lodge, 4.7 km northeast of the Summit Observatory at an elevation of 879 m. Owned by the New York State Department of Environmental Conservation (DEC), most of the same parameters are measured as at the Summit Observatory through a collaborative effort with ASRC. Trace gases measured at the Lodge site by ASRC include NO, NO_2, and SO_2, as well as PM2.5, beginning in 2002. This complements DEC who monitors trace gases (O_3, SO_2) and aerosols plus standard meteorological parameters. Lodge data tends to track local sources of pollution - in contrast to data from the Summit Observatory.

[a] ASRC Report 1988-1991, ASRC publication 1578, Dec. 1992, p.27.

ASRC WHITEFACE MOUNTAIN FIELD STATION

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The Atmospheric Sciences Research Center (ASRC) and Whiteface Mountain Field Station was established on February 16, 1961, by the State University of New York as a University-wide center for the purpose of promoting and encouraging programs in basic and applied sciences related to the atmosphere. The mission of the research at ASRC's Whiteface Observatory is to enhance our fundamental understanding of the chemical and physical nature of the atmosphere, and to apply that knowledge to study the interaction of chemical, physical, geological, and biological processes impacting our environment. The main facility of the Whiteface Mountain Field Station is located at the Marble Mountain Lodge (110 Marble Mountain Lane, Town of Wilmington, NY), perched on the shoulder of the Whiteface massif at an elevation of 604 meters. At the Marble Mountain Lodge location, ASRC researchers

sample the chemical content of the atmosphere, including pollutants and particulates, and continuously monitor weather conditions. Precipitation is measured at the Lodge site as part of the National Atmospheric Deposition Program. In October of 2012 a flow tower and passive ammonia sampler were added to estimate dry deposition as part of the EPA's secondary standard pilot program. Atmospheric trace gases, particulates, and meteorological measurements are made at a monitoring site located 30m above the lodge. Monitored gases include carbon monoxide (CO), sulfur dioxide (SO2), ozone (O3), and nitrous oxides (NOx). Condensed phase pollutants measured include sulfates and nitrates that result in acid rain, as well as black carbon. The Whiteface Mountain summit observatory makes many of the same measurements and weather observations, but is situated at 1483 meters (4867') elevation.
The ASRC Whiteface Mountain field station is ideally suited to conduct environmental monitoring programs and support a range of ecological research studies. One of the primary reasons for tracking atmospheric trace gases and particulates at Whiteface is to gauge the effectiveness of pollution controls. Acid rain, ozone, and particulate matter research and monitoring programs have been very successful at the ASRC Whiteface Mountain Field Station for over forty years. The opportunity to educate and inform the public about the atmospheric monitoring and research activities being conducted at the ASRC Whiteface Mountain Field Station is critical in promoting scientifically sound public policy. Such public outreach efforts help to fulfill an important part of the ASRC mission to enhance fundamental understanding of the chemical and physical nature of the atmosphere.

CORRELATION BETWEEN AMBIENT ULTRAFINE PARTICLE EVENTS AT TWO GEOGRAPHICALLY DISPLACED MONITORS IN NEW YORK CITY

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There have been numerous short-term studies of ambient ultrafine particle behavior at single locations, but relatively little data has been gathered from long-term measurements at multiple geographical sites in urban environments. In this study, ultrafine particle size distributions were simultaneously measured at two locations in the New York State Ambient Air Monitoring Network from June 2009 to June 2010, using an Ultrafine Particle Monitor (UFP Monitor, Model 3031, TSI, Inc.) at 15-minute intervals. The first monitor was installed at Queens College, a well-instrumented monitoring site representative of the New York City metropolitan area. The second monitor was installed 17 miles east of Queens College at the Eisenhower Park site on Long Island. The UFP Monitor used for this study is specifically designed for long-term ambient monitoring and provides particle number in six bins over the size range from 20 to 500 nm. Over the course of the study, a series of high particle concentration events occurred during which UFP measurements at both sites were highly correlated with each other despite their geographic separation. The ambient particle behavior during these events, as well as the influence of other factors such as meteorological variables, is examined in detail. Similar events during which the UFP measurements at both sites were not correlated are also examined. These findings yield insight into the behavior of ultrafine particles in urban airsheds, and have implications for designing strategies for long-term ambient monitoring of UFPs.

DEVELOPMENT OF A NEW ELECTROSTATIC DIESEL PARTICULATE TRAP

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A high voltage electrostatic precipitator (ESP) filter has been designed and developed for operation with a diesel truck to provide electrostatic filtering of diesel exhaust particulates. A specific goal of the study is to optimize the ESP design such that the deployed unit is compact in size and most effective for removal of particles smaller than 200 nm, which are sizes that contribute to the majority of the diesel exhaust particulate numbers, PM 2.5 and PM 10. The ESP design will be optimized to ensure that it can be operated over long collection times and produces a minimal pressure drop in the tailpipe system. A combination of fluid flow, electric field, and particle trajectory modeling will be used by simulations in both MATLAB and ANSYS FLUENT. In designing the proposed unit, a prototype will be fabricated and tested under controlled conditions in the lab and in the field with a diesel truck. Experimental results will be compared to both computer models and theory to determine the actual efficiency of the ESP, and if any empirical scaling equations are required. The project aims to give an overview of the capabilities of ESP systems to filter diesel exhaust.

IMPACT OF OZONE TRANSPORT MITIGATION POLICY THROUGH THE NOX SIP CALL ON CHILDREN'S RESPIRATORY HOSPITALIZATIONS IN NEW YORK STATE

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Background: Limited studies have examined the impacts of federal environmental policy on outdoor pollutants and health outcomes. The objective of this study was to examine the health impact on children of the NOx SIP call, a US Environmental Protection Agency rule that required Northeast states and the District of Columbia to submit state implementation plans (SIPs) that address the regional transport of ozone, through reductions in nitrogen oxides (NOx) emissions, implemented fully in 2003.

Methods: A time-series analysis was used to assess the health impacts of the implementation of the NOx SIP call in NYS. Outdoor ozone concentrations and child respiratory hospitalizations were compared between baseline (1997-2000), partial-implementation (2001-2003), and post-implementation (2004-2006) periods, adjusting for temporal trends and meteorological factors.

Results: Summertime ambient ozone concentrations statewide significantly declined during the post-intervention period. After adjusting for temporal trends, particulate matter ($PM_{2.5}$), and meteorological variables, significant declines in child respiratory admissions were observed following the implementation of the NOx SIP call in the Long Island (-11.1%, 95% CI: -20.0,-1.3), NYC Metro (-21.7%, 95% CI: -24.5,-18.7), Upper Hudson (-21.3%, 95% CI:-34.2,-5.8), Eastern Ontario (-23.1%, 95% CI: -36.3, -7,2), and Central (-35.3%, 95% CI:-44.3,-24.9) regions.

Conclusions: This research found that positive public health impacts on children were associated with an environmental policy aimed to reduce outdoor ozone concentrations. The findings demonstrated encouragement that federal mandates to reduce exposure to outdoor pollutants have health benefits.

IMPACTS OF CFPP SHUTDOWN AND ULSD ADOPTION ON MICRO-ENVIRONMENTAL AIR QUALITY IN ROCHESTER, NY

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In early 2008, a large coal-fired power plant (CFPP), located northwest to the downtown Rochester, was shut down for conversion to natural gas. Another major change in emission sources around that period was the adoption of ultra-low-sulfur diesel (ULSD) for diesel vehicles, starting from late 2006. The micro-environmental air quality in Rochester area was affected by the CFPP shutdown and the ULSD adoption from late 2006 to early 2008. However, it is important for air quality management to elucidate their individual impacts.

We combined field measurements and air quality modeling to separate the impacts of the two emission reduction measures on a highway intersection environment in Rochester. A novel multi-scale structure is implemented in the Comprehensive Turbulent Aerosol Dynamics and Gas Chemistry (CTAG) model to characterize the micro-environmental air quality near a large highway intersection. The major findings are 1) both CFPP shutdown and ULSD adoption improved the micro-environmental air quality near the intersection; 2) for the near-road communities, the ULSD adoption resulted in greater reductions in UFP concentrations than the CFPP shutdown, and the magnitude of the reduction varies with the fraction of heavy-duty diesel trucks on the highways; 3) there are large variations in terms of the magnitudes of UFP reductions within the community; and 4) it is also observed from field measurements that the CFPP shutdown had a larger regional impact on air quality than ULSD adoption.

INJECTION OF METEOROLOGICAL FACTORS INTO SATELLITE ESTIMATES OF SURFACE PM2.5

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Prior efforts to connect surface PM2.5 to satellite retrieval of aerosol optical depth (AOD) have been mainly made based on statistical approaches connecting AIRNow PM2.5 measurements and satellite AOD for different seasons and geographic regions. However, this approach does not account for complex aerosol behavior including planetary boundary layer (PBL) dynamics. In another approach used operationally within the IDEA (Infusing satellite Data into Environmental air quality Applications) product, the use of a global model (GEOS-CHEM) is used to estimate on a daily basis, the spatial relationship between forecast PM2.5and column path AOD, which can then be used with satellite AOD estimates. However, one difficulty with the GEOS-CHEM approach is the poor spatial resolution symptomatic of global models with a spatial resolution of 2.5 degrees, which fails to particularly resolve issues in the urban/nonurban interface To improve on this, the WRF/CMAQ model is a high-resolution algorithm that accounts for physically based meteorological factors and surface boundary conditions including emission inventories to estimate particulate concentrations and vertical distributions; therefore, it is considered in our work.

Because of the complexity observed in the PM2.5-AOD relationship, our focal point is the application of a neural network for better describing the non-linear conditions surrounding the PM2.5-AOD environment while at the same time investigating other dependences such as additional factors or seasonal changes. Neural networks have proven to perform well in different areas of study, including atmospheric sciences where many complex relationships cannot be sufficiently understood by using statistical approaches.
As part of our analysis, we first explore the baseline effectiveness of AOD and PBL as strong factors in estimating PM2.5 in a local experiment using data collected at one site in New York City. Then, we expand our analysis to a regional domain where daily estimations are compared based on site location and season. In our local test, we find very good agreement of the neural network estimator when AOD, PBL, and seasonality are ingested (R~0.94 in summer). Next, we test our regional network and compare it with the GEOS-CHEM product. In particular, we find significant improvement of the NN approach with better correlation and less bias in comparison with GEOS-CHEM. Further, we show that further improvements are obtained if additional satellite information, including satellite/view geometry and land surface reflection, is included. Finally, comparisons with WRF/CMAQ PM25 are included.

LONG-TERM TRENDS OF AIR POLLUTANTS IN NEW YORK STATE: URBAN-RURAL CONTRASTS

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Over the past few decades the Department of Environmental Conservation has monitored particle and gas phase pollutants at various sites throughout New York State. The data are used to determine compliance with the federal National Ambient Air Quality Standards (NAAQS). In the case of O_3 and hourly $PM_{2.5}$ mass, the data are also used for air quality forecasts. Public health advisories are issued when these forecasts indicate exceedance of the air quality standards. In addition, the measurements provide a database for determining long-term trends used to assess the impact of emission controls (e.g., SO_X and NO_X). In general, measurements indicate declining trends for most pollutants consistent with emission reductions. In this poster we characterize the long-term trends in particle and gas phase species at both urban and rural locations in New York State. The impact of emission reductions on $PM_{2.5}$ particle composition is also assessed.

RECENT TRENDS AND 21ST CENTURY PROJECTIONS OF OZONE POLLUTION EXTREMES OVER THE NORTHEASTERN USA DURING SUMMER

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Previous studies have documented reductions in summertime surface ozone over the eastern U.S. resulting from emission controls (e.g., the "NOx SIP Call") over recent decades. We apply methods from extreme value theory to characterize recent changes in extreme ozone events over the northeastern U.S (analogous to the hydrological "100-year flood"). Specifically, we estimate 1-year return levels for maximum daily 8-hour average (MDA8) ozone observed by the Clean Air Status and Trends Network (CASTNet) and find 2-16 ppb decreases from 1988-1998 to 1999-2009. With the GFDL CM3 chemistry-climate model, we examine the role of climate versus emission changes on 1-year return levels over the northeastern United States under the Representative Concentration Pathway (RCP) 4.5 scenario. In this scenario, U.S. NOx emissions decrease by ~80% and global mean temperatures warm by ~2°C over the 21st century. Another scenario, with well-mixed greenhouse gases following RCP4.5 but air pollutant and precursor emissions held at 2005 levels (RCP4.5_WMGG), isolates the impacts of climate change alone. The availability of three ensemble members enables an assessment of the climate signal relative to year-to-year weather variability ("climate noise"). Since the GFDL CM3 MDA8 O3 is biased high relative to the summertime eastern U.S. O3 measurements (a common feature in the current generation of models), we develop a correction method based on quantile-mapping that preserves the temporal changes in MDA8 O3 as simulated with the chemistry-climate model. We evaluate the model to show that it adequately represents the observed surface ozone response to NOx emission controls, at least at the mid-to-high part of the distribution, from the 1990s to the 2000s, implying that it is suitable for assessing the evolution of surface O3 in scenarios with changing NOx emissions (e.g., RCP4.5). The model projects a strong decline in the number of high O3 pollution events under the RCP4.5 scenario, with the probabilistic 1-year return level for MDA8 O3 decreasing strongly over the first half of the 21st century, resulting in almost zero days exceeding the current 75 ppb

threshold of the U.S. ozone standard by the middle of the 21st century. In contrast, under the RCP4.5_WMGG scenario (i.e., air pollutant emissions remain at present-day levels but global mean temperatures warm), the model simulates similar or higher (up to 3 ppb, the so-called "climate penalty") 1-year return levels for MDA8 O3 by 2100 as compared to present-day values.

Risk of Acute Myocardial Infarction Associated with Increased Particulate Matter Concentration: Effect Modification by Air Mass Back Trajectory

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Background: We and others have shown that increased particulate air pollutant concentrations in the previous hours and days have been associated with increased risks of myocardial infarction (i.e., heart attack). Little is known about the relationships between air pollution and specific subsets of myocardial infarction (MI), such as ST-elevation MI (STEMI) and non ST-elevation MI (NSTEMI), whether all particle sizes are associated with this increased risk, and whether that is modified by where the particles originated.

Methods and Results: Using patients with STEMI (n=338) and NSTEMI (n=339), hourly ambient fine particle (<2.5 um; $PM_{2.5}$), ultrafine particle (10-100nm; UFP), and accumulation mode particle (100-500nm; AMP) concentrations, as well as case-crossover methods, we found a significant 18% increase in the risk of STEMI associated with each 7.1 $\mu g/m^3$ increase in $PM_{2.5}$ concentration in the hour prior to MI onset. We found no such association with NSTEMI. Estimates of the relative risk of STEMI associated with increased UFP and AMP concentrations in the previous 1 to 96 hours were greater than 1.0, but not significant. When the wind arrived from the west-southwest (WSW) direction in the past 24 hours, the risk of STEMI associated with increased $PM_{2.5}$ concentration was significantly higher than other directions.

Conclusions: Increased $PM_{2.5}$ concentrations, but not UFP or AMP, in the hour prior to MI onset were associated with an increased risk of STEMI. Further investigation into mechanisms by which PM can preferentially trigger STEMI over NSTEMI within this rapid time scale is needed. Since relative risk estimates were higher when the air mass passed through the WSW quadrant in the past 24 hours, there may be specific components of the ambient aerosol that are more potent in triggering STEMIs. This direction is associated with the substantial emissions from coal-fired power plants and other industrial sources of the Ohio River Valley. Further studies will examine compositional data in Rochester, to explore differences in composition between directions. Since many of the pollution sources upwind of Rochester are undergoing modifications to reduce their emissions, future studies may be able to see reductions in the health effects of particles from these sources.

Shifting Seasonal Cycles of Surface Ozone: The Role of Regional vs. Global Emission Changes

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Surface-level ozone seasonal cycles vary in shape and in magnitude with location. These variations reflect local contributions, whose influence differs each month, from regional anthropogenic and natural precursor emissions, as well as ozone transported from various sources. We focus on the seasonal cycle over recent decades in the northeastern U.S. In the Northeast, there are peak ozone values in the summer months due to high regional NOx emissions, abundant sunlight and isoprene emissions during this season. Parrish et al. [2013] report a shift in seasonal cycles to earlier months in spring over recent decades at remote sites. We investigate here the role of changing global and regional ozone precursor emissions over the 21st century.

With GFDL's fully coupled climate chemistry model CM3, we use selected Representative Concentration Pathways (RCP) scenarios developed for the Coupled Model Intercomparison Project Phase 5 (CMIP5) in support of IPCC AR5, and several sensitivity simulations, to examine the impacts of regional and global emissions on surface ozone seasonal cycles throughout the 21st century. In RCP8.5, an extreme climate warming scenario, methane doubles from the present to the end of the 21st century, whereas in RCP4.5, a more moderate climate warming scenario, there is a small (~10%) decrease of methane. For RCP8.5, global mean surface temperature increases by 4.5 K, and for RCP4.5, by 1.4 K. In RCP8.5 and RCP4.5, NOx emissions decrease globally by 70.1% and 52.3%, respectively, by the end of the 21st century. These regional NOx reductions shift the ozone maximum in the Northeast from summer to late winter/early spring, resembling the present-day seasonal cycle over the InterMountain West (where we see lower NOx emissions combined with larger higher altitude transported "background" ozone, which leads to a weak spring maximum). We further find that in RCP8.5, the end of 21st century seasonal cycles in the Northeast increase by more than 5-15 ppb in each month due to the doubling of global methane. Across present-day high-NOx regions at northern mid-latitudes, surface ozone consistently decreases during the summer and fall months as NOx emissions decline globally, but in the RCP8.5 scenario increases during winter and early spring as CH_4 rises.

SPATIAL EXTENT OF NEW PARTICLE FORMATION AND GROWTH EVENTS

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We measured particle number concentrations and size distributions at two locations in New York State separated by a little over 300 km. The sites are Pinnacle State Park in Addison, NY in southwestern upstate New York, and Queens College in the borough of Queens, New York City. Relevant measurements at the Addison site consisted of paired nano- and long-tube SMPS systems to cover the size range from 5 to ~700 nm mobility size, and a 3783 water-based Environmental Particle Counter (EPC) for concentrations of particles greater than 7 nm diameter. At the Queens College site the size distributions were measured with a Fast Mobility Particle Sizer, and a second 3783 EPC. Simultaneous measurements at the two sites were carried out from April through September 2012.

The simultaneous nature of the measurements, combined with the mid-range separation distance between the sites allow us to pose and address a number of questions related to the spatial extent of new particle formation and growth events. For example, how well correlated (if at all) are particle formation and growth events at these two sites? If they are related, do they tend to occur simultaneously, or separated by some "transit" time? What are the frequencies of rural versus urban events? These and other questions will be addressed in this presentation.

The possibility of identifying new particle formation and growth events from only the concentration data from the EPCs was investigated. These events can be identified by looking for values above a threshold determined from a long period average and by a duration greater than about six hours. For Pinnacle State Park, the occurrence of these events as identified from EPC data compares favorably with a more detailed analysis of the aerosol size distribution. This technique does not work well for the Queens College data because of substantial variations in aerosol concentrations due to local sources.

TOWARDS THE DEVELOPMENT OF A SENSOR NETWORK FOR ULTRAFINE PARTICLE MEASUREMENTS AT A HIGH-SPATIAL AND TEMPORAL RESOLUTION

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Aerosol particles are known to modulate Earth's climate and contribute to adverse urban air quality. Recent studies have shown a strong correlation between ambient fine particle (i.e., particles smaller than 2.5 μm) concentrations and increased mortality rates in urban areas. Within this size range, particles smaller than 100 nm (ultrafine particles) are of particular concern to human health because of the long lifetime of these particles in the environment and the ability of these particles to penetrate deep into the respiratory system. Ultrafine particles have a large number of sources in urban environments, and the population characteristics of these particles can dramatically change over short spatial and temporal scales. Accurate characterization of these particles, therefore, requires their measurement at high spatial and temporal resolution. However, the large cost, size, and power requirements of the existing instruments make such deployments difficult.

Towards addressing these challenges, an innovative ultrafine sensor that can be deployed as a part of a distributed, telemetric sensing network in urban areas is being designed and developed in our group. The Real-time Electro-integrated Mobility Sensor (REMS) is designed to be a network-ready ultrafine particle sensor, consisting of a tailored electrode classifier (TEC) and Electro-Integrated Sensor (EIS). In the REMS, charged particles are condensed out onto the electrodes of the TEC and the time taken to collect a threshold charge level is measured. The theory and working principle of the REMS will be presented and the preliminary progress in developing the instrument will be highlighted.

TRACKING TRENDS IN OZONE PRODUCTION EFFICIENCY AT PINNACLE STATE PARK

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Ozone Production Efficiency (OPE) in the atmosphere is based on the linear regression of ambient O_3 and NOz, where NOz is calculated from measured NOy (the total of nitrogen oxides including NO, NO_2, HNO_3, HNO_2, N_2O_5, NO_3^-) – NOx (= NO + NO_2). The slope of the O_3 – NOz regression line (the OPE) is an estimate of the number of O_3 molecules formed per NOx molecule

consumed in a photochemically aged air mass. Trends in OPEs have important implications in assessing the progress of regulatory actions in the attainment of the O_3 National Ambient Air Quality Standard (NAAQS).

The analyses presented utilize air quality measurements carried out at Pinnacle State Park (PSP) in Addison, NY, since the mid-1990s. The site is located in a rural area in the New York/Pennsylvania Twin Tiers Region near the village of Addison (population ~1,800) at an elevation of 515m. Instrumentation is housed in an Eco shelter adjacent to a 10m meteorological tower. The site is typically influenced by aged air masses that flow from the west, southwest, and transported emissions from source regions in the Midwest.

We explore the trends in oxidant precursors and OPEs at PSP over the past fifteen years and the factors influencing and contributing to these trends and associated uncertainties. The analyses demonstrate the utility of long-term environmental measurements in monitoring the efficacy of emission controls in achieving anticipated environmental/air quality outcomes, elements fundamental to establishing an "accountable" air quality management system.

USING THE ELECTRICAL LOW PRESSURE IMPACTOR TO MEASURE AND COLLECT SIZE-SEGREGATED COMBUSTION AEROSOLS

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While several methods exist for the measurement of particle size distributions in real time, they do not yield information on particle composition or morphology. The composition and morphology of aerosol particles tend to be poorly characterized, especially for particles less than 1 micrometer, despite their potential impact on phenomena such as health effects and radiative forcing. A potential methodology for simultaneous particle number concentration measurement and particle characterization is through the use of an Electrical Low Pressure Impactor (ELPI, Dekati, Ltd.) instrument that measures particle concentrations over 12 size bins from 17 nm to 6.8 microns by depositing particles on a series of stages. Subsequent examination of the deposited particles via chemical and microscopic analysis can yield valuable data on particle composition and morphology. A pilot test of this methodology conducted at the Queens College, NY, Ambient Air Quality Monitoring Site from June to September 2012 during a field intensive to measure ambient aerosols demonstrated that while particle concentration data can be readily obtained, greater sophistication is needed in the methodology to capture particles for subsequent analysis. The current project seeks to refine this methodology through the use of an aerosol produced in the laboratory by the Combustion Aerosol Standard (CAST, Jing, Ltd.) and delivered to the ELPI via a custom-built aerosol chamber. Control of the CAST parameters allows an aerosol to be produced with a narrow particle size distribution and specified geometric mean particle sizes from 20 to 175 nm. The aerosol can be targeted at a specific ELPI size stage at a controlled concentration, serving as a test aerosol in further investigations to characterize the impacts of various parameters in the particle capture methodology (e.g., stage substrate material, particle elution method, acceptable particle density) on chemical and morphological particle assessments The work presented here is a proof-of-concept study demonstrating the ability to direct an aerosol at specific ELPI stage(s) with a controlled amount of deposition, and the beginning stages of investigation into the viability of various substrate materials for capturing sub-micron particles on these stages for analysis.

CELLULOSIC BIOFUEL POTENTIAL IN THE NORTHEAST: A SCENARIO ANALYSIS

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Secure access to energy and food are two of the main future challenges facing the Northeast region of the U.S. A strategy of relying on traditional biofuel feedstocks (e.g., corn and oil seed) can compete with food production over desirable land and water resources and in any case is not likely to exploit the region's comparative advantages. An alternative is advanced biofuel feedstocks in the forms of forest growth and woody wastes, in which the Northeast has abundant endowments. In addition, the federal government has committed to require 21 billion gallons of next generation biofuel production by the year 2022.

This study introduces the production of biofuel, in particular cellulosic ethanol from woody biomass in the Northeast as an alternative to gasoline. We evaluate both the capacity for its production and its cost competitiveness using an input-output model of consumption, production, and trade in the thirteen-state region. The model minimizes resource use required to satisfy given consumer demand subject to the technological options in place and resource constraints. We compile data quantifying state-level biofuel feedstock endowments, and add as an alternative the technological requirements for cellulosic ethanol production using information located in the technical literature.

We then evaluate the consequences the several scenarios that mandate alternative fuel production by restricting imports of petroleum products or incentivizing the production of biofuels through cost subsidies. Based on our initial investigation, we find that the region can produce significant amounts of advanced biofuel, up to 5.36 billion gallons of cellulosic ethanol per year, displacing nearly 17% of motor gasoline consumption in the region. However, utilizing this potential for cellulosic ethanol production requires import restrictions, or else subsidies, to make it economically competitive. Reliance on import restrictions alone would increase the unit price of motor fuel by up to 10%. Depending on the amount of subsidy, biofuel production could be competitive in some states but not in others. With a subsidy of $.36 per gallon, the entire potential could be achieved.

HIGH RESOLUTION IMAGING AND CHARACTERIZATION OF COMBUSTION EMISSION NANOPARTICLES PRODUCED FROM ADVANCED TECHNOLOGY AND OUTDOOR WOOD BURNING BOILERS, AND THEIR IMPACT ON HUMAN LUNG EPITHELIUM

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Currently there is extensive use of many types of wood burning stoves and boilers around the world, and some studies have linked these types of wood combustion emissions to specific human cardiovascular and respiratory illnesses. However there is yet no clear mechanism to explain wood combustion emission particulate interactions with respiratory tract cells (inhalation route of entry), or target cells elsewhere producing a specific pathology. With the present development of new advanced technology wood burning boilers, there are new questions about the amount and types of combustion emission particulates produced—and especially the particulates generated in the nano-size range (under 100 nm) and released by outdoor wood burning boilers, as well as the new advanced technology auto-regulated wood burning heating units. At present, the types of wood combustion nanoparticulates that are produced during the various phases of the burn cycle in the outdoor conventional and new, advanced-technology wood burner/boilers have not been defined, nor tested for possible human respiratory interactions.

This investigation specifically examines collected combustion emission nanoparticles produced from both advanced technology, and conventional outdoor wood burning boilers, to capture and characterize the nanoparticles produced at specific times in the burn cycle (start-up, steady state, and periods of high carbon monoxide production), under experimental conditions, and using the same fuel (oak logs). Nanoparticulates were harvested using two new insertion devices* for direct combustion stream capture in the dilution tunnel flue (*these were developed in this research investigation). Nanoparticulates were also recovered from Millipore quartz fiber filters (vacuum capture) for comparison of particulates. The wood combustion emission nanoparticulates were morphologically characterized using high-resolution transmission electron microscopy (HRTEM) combined with compositional analysis (x-ray elemental microanalysis), and selected area electron diffraction (SAED). Human lung cell monolayers exposed in vitro to the same

nanoparticles using a dose/time toxicity assay were analyzed for either (a) viability by light microscopy (erythrosin-B staining for necrosis), or (b) nanoparticle-cell surface interactions and cell morphology by scanning electron microscopy (SEM). Control and nanoparticle-exposed monolayers were also thin sectioned for HRTEM and ultrastructurally evaluated to verify normal/ abnormal lung cell morphology, nanoparticle fate, and nanoparticle-lung cell interactions.

INNOVATIVE FINE PARTICULATE MEASUREMENT SYSTEMS FOR THE WOOD STOVE DESIGN CHALLENGE

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As the price of heating oil has increased in the U.S., more residents are returning to wood heat. Most existing wood stoves date from before the EPA implemented emissions certification requirements for these devices. Even those wood stoves that meet EPA's Phase II requirements often have unacceptably high emissions once in use. This is due to several factors including fuel quality, operator habits, and design. While the EPA is developing new regulations, the test method used for certification is not representative of in-use performance, and the performance criteria in the test fall short of high efficiency or low emissions.

Designs that improve combustion and emission performance, thermal efficiency, and operational variability are needed in the U.S. heating market. The Alliance for Green Heat and *Popular Mechanics* Magazine has initiated the Wood Stove Design Challenge (WSDC) to address these needs by developing a competition for manufacturers, innovators, and university teams working toward these objectives.

This project seeks to develop a WSDC energy efficiency and emissions testing protocol which reduces the variability in fuel and operator. The current test method (EPA Method 28 WHH) involves testing stoves using a dilution tunnel. Seeing that the WSDC is held at the mall in Washington DC, this test method does not suit. Recently, new particulate measurement systems have been introduced in Europe, both the Wöhler SM 500 and Testo 380. Both analyzers are a low-cost option and offer the advantage of ease and portability. Both systems measure PM and include O2 and CO sensors. The Wöhler uses an oscillating filter sensor which collects the particulates, causing a change in frequency, relating to a mass increase. The Testo also uses an oscillating particulate sensor, but the particulates are impacted on a plate. A correlation correction for the expected low collection efficiency of the very fine particles is used. Similar to the current test method, the Testo system dilutes the exhaust gas, the Wöhler unit does not. Both systems are able to produce live measurements with a resolution down to 0.1 mg. To determine the accuracy, precision, instrument range, and applicability for use in the WSDE for thermal efficiency and emissions, these portable direct measure analyzers, an evaluation will be conducted while simultaneously using the standard methods for determining the emissions.

There is, also, interest in the potential use of instruments of this type for field evaluation of the performance of both stoves and boilers.

LOOKING AT SUB-DAILY AVERAGING TIMES FOR PM 2.5 CONCENTRATIONS IN COMMUNITIES WHERE WOOD BURNING IS COMMON

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Introduction: Recent health literature has shown a link between sub-daily increases in $PM_{2.5}$ concentrations and respiratory and cardiovascular health effects. Episodic increases in $PM_{2.5}$ a few hours or less have been associated with adverse changes in cardiovascular function. Wood smoke is typically a localized, rural problem attributed mostly to wood-burning appliances, which are high emitters of $PM_{2.5}$. This study used data from existing datasets to characterize the frequency distribution of incremental changes in $PM_{2.5}$ measured at a NYS DEC $PM_{2.5}$ monitor and at six $PM_{2.5}$ monitors located in wood burning communities in northern New York from November 2008-April 2009.

Methods: The data analysis uses previous NESCAUM generated data reported in "Spatial Modeling and Monitoring of Residential Woodsmoke across a Non-Urban Upstate New York Region- February 2010" (http://www.nyserda.ny.gov/Publications/Research-and-Development-Technical-Reports/Biomass-Reports.aspx) and NYS DEC monitoring data. We used the one-hour mean $PM_{2.5}$ concentrations from the NYS DEC site and for each of the six community sites to calculate one- and two-hour moving averages. The rolling one- and two-hour averages were used to characterize incremental changes in $PM_{2.5}$. The Whiteface DEC $PM_{2.5}$ monitoring site provided hourly data and was used as an indicator of regional background when analyzing the data from the six other monitoring sites.

Meteorological data from the NYSDEC site and Weather Underground (www.wunderground.com) were used to obtain hourly wind direction and wind speed data to be able to determine whether rises in $PM_{2.5}$ concentrations at the wood burning community monitoring locations might be attributable to regional or local events.

Results: The data analysis indicated that there were several regional $PM_{2.5}$ events that raised concentrations at multiple monitors (≥10 $\mu g/m^3$ above background). However, there were some $PM_{2.5}$ events (two-hour rolling averages up to 75 $\mu g/m^3$; two-hour incremental increases up to 47 $\mu g/m^3$) that were observed at a single or a limited number of the monitoring stations, suggesting local sources account for part of the observed impacts.

Discussion: Understanding the frequency with which significant short-term incremental increases of $PM_{2.5}$ exposure occur regionally and locally can give us a better understanding of how likely short-term incremental increases in $PM_{2.5}$ (from local sources including woodsmoke) will affect air quality and health risks in rural communities.

MONITORING CO OFF-GASSED FROM WOOD PELLETS IN IN-USE STORAGE BINS

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There is a significant health concern for the carbon monoxide (CO) off-gassed from wood pellets in storage bins. Continuous CO measurements have been made in a number of storage bins containing wood pellets. Calibrated CO sensors (0-500 ppm) were installed in the Walker Center and Energy Cabin at the Clarkson University (Potsdam, NY); the Wild Center in Tupper Lake, NY; three locations in a middle school; in an external storage bin at an elementary school; and in a residential basement . In three of these locations, continuous measurements of CO_2, O_2, relative humidity, and temperature were also made. $PM_{2.5}$ was measured in one of the bins. Preliminary results from the residential storage bin showed that CO rose from 2 to 14 ppm in approximately 6 hours after the introduction of fresh wood pellets. This CO concentration exceeds the 8-hour standard of 9 ppm from the National Ambient Air Quality Standards, indicating the need of increased ventilation in storage rooms.

OFF-GAS EMISSION KINETICS OF CO AND VOCS FROM WOOD PELLETS MANUFACTURED IN THE NORTHEASTERN US

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The interest in biomass fuel is continuing to expand in the northeastern US. Wood pellets have become a popular choice for biomass due to their ease in transportation and storage; hence, it has become necessary to better understand their environmental health impacts. While immediate health concern with wood pellet storage is the off-gassing of carbon monoxide, another concern is the adverse impact of indoor air quality due to the increase of volatile organic compounds (VOCs) off-gassing from wood pellets stored indoors. The aim of this study is to better understand the emission rates of CO and VOCs from hardwood, softwood, and a blended mixture of pellets in order to provide a safer environment for building occupants. A 30-day experiment was carried out using nine sealed 20 gallon stainless steel barrels containing, hardwood, softwood and blended wood pellets. Carbon monoxide, carbon dioxide, O2 and relative humidity along with predominant VOCs were collected in the air samples. The VOCs were successfully identified with a gas chromatography/mass spectrometry. Thirty days of analysis provided emission curves for CO and a variety of VOCs. Predominant VOCs found during this preliminary study were methanol, pentane, pentenal, and hexenal. Several trace amounts of acetaldehyde, isopropyl alcohol, heptane, octane, 2-heptanone, α-pinene, and β-pinene were also present in softwood emissions. Each of the compounds off-gassed at a faster rate within the first few days then plateaued and remained at a relatively constant concentration. Carbon monoxide concentrations plateaued within 10 days; the concentration of CO inside the barrels with hardwood pellets exceeded 400 ppm, while the concentration inside the ones with softwood and blended pellets exceeded 800 ppm. The emission of CO shows an exponential rise to maximal values indicating self-limiting reactions. A lumped kinetics model for these experiments has been established, accounting for the off-gassing rate of CO and the depletion of O2. In conclusion, the softwood pellets were found to emit more VOCs than hardwood pellets and typically in higher concentrations for both VOCs and CO. The blended mixture of pellets appeared to contain more softwood than hardwood based on the data collected. Understanding the CO and VOC species and emission rates will allow for better ventilation designs for stored wood pellets in homes, schools, and businesses.

THE IMPACT OF THERMAL STORAGE ON WOOD PELLET BOILER EFFICIENCY AND EMISSIONS

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Advanced wood pellet boilers work at their highest efficiency at full load. However, during the early and late portions of the heating season (shoulder months), the building demand for heat is such that the unit cannot operate continuously at full load. Current systems typically run continuously at partial load resulting in lower efficiency and greater emissions per unit heat delivered. An alternative is to add thermal storage, a large, insulated tank holding hot water that then provides the heat to the building to meet the demand. A typical system would operate between 160ºF and 190ºF so that the boiler would operate at full load until the stored water was at the peak temperature. It would then shut down and the hot water from the storage tank would be used to heat the building. Once the temperature drops below the lower set point, the boiler comes back on and heats the water back to the upper set point temperature. Thus, the boiler runs intermittently at full load producing heat at its peak efficiency. We are testing such systems at a variety of scales, from residential boilers being installed in Saranac Lake, NY to a 150 kW boiler at Clarkson University, to the 500 kW boiler at the Wild Center in Tupper Lake, NY. The thermal storage system at Clarkson is operational and will provide data beginning in October when the building demand warrants heating. We may have results from the residential units as well. These results should demonstrate the cost effectiveness of planning any new biomass burning system to include thermal storage as part of the overall design.

UNCONVENTIONAL WOOD CHIP DRYING FOR HIGH-EFFICIENCY BIOMASS HEATING MARKET

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Biomass, specifically wood chips, represents a low-cost, abundant and renewable energy source in New York State and throughout the Northeast. The burning of dried wood chips in locally manufactured high-efficiency boilers results in efficiencies above 93%. Reducing the moisture content of “green” wood chips from 50 wt-% to 20 wt-%, the heating value of the biomass is doubled. This improves the fuel quality, thus providing an economically viable, environmentally friendly fuel for a variety of end users, including residential, district, and commercial heating applications.

In this NYSERDA-funded project, Troy Boiler Works and Rensselaer Polytechnic Institute have collaborated to design and test a radical wood chip/biomass drying process. The novel process utilizes a vacuum to minimize the thermal energy required to dry “green” wood chips to a desired level. The highly scalable process is designed for continuous operation through the use of a custom-designed screw conveyor.

An initial proof-of-concept study was performed on the laboratory scale at RPI. Here, a scaled down batch version of the process was developed to explore the effect of multiple process parameters including residence time, vacuum level, and operating temperature. Testing showed that vacuum operation increased the drying rate over 20% relative to atmospheric pressure at temperatures below 200°F. The results from this work where then used to design and build a pilot-scale demonstration process capable of drying 100 lb/hour of “green” wood chips.

A key outcome of this project will be the development of a standardized wood chip product to bring to the biomass heating market. The technology being developed will enable the growth and development of the regional biomass heating industry.

CARBON SEQUESTRATION IN NEW YORK STATE: A DECADE OF RESEARCH

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The vast majority of scientists agree that global climate change is occurring, and that greenhouse gasses such as carbon dioxide (CO_2) are a major contributor. The geologic sequestration of carbon dioxide has emerged as one of the leading methods for reducing the emission of greenhouse gases. Over the past 10 years, the geologists at the New York State Museum (State Geological Survey) have been involved in several NYSERDA-supported projects that investigate the potential for sequestration of CO_2 in New York State. Sites of past and present projects include the Potsdam Sandstone in western NY, Queenston Formation in central NY, Newark Rift Basin in the tri-state area, and offshore continental shelf south of Long Island. The geology of these areas is never simple, and each study presents its own unique challenges that must be addressed through detailed scientific research. Although these projects are not all success stories, the data and analyses associated with each have added a wealth of knowledge to both the climate change community and overall geologic understanding of New York State.

COST-EFFECTIVE EVALUATION OF THE IMPACT OF SEA LEVEL RISE ON FUTURE FLOOD HAZARDS ACROSS NEW YORK STATE

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Climate change is projected to increase average global sea levels, which may result in a relative increase in sea level of more than 1.3m of sea level rise (SLR) by 2080 for New York State coastal areas connected to the Atlantic Ocean. Future flood events will propagate across the increasing sea level and result in increased flooding and damages as compared to past events. Identification and recognition of the future flood exposure can inform planning efforts and facilitate future flood loss reductions through proactive adaptation efforts. Evaluation of the change in flood characteristics due to sea level rise must be undertaken to inform these efforts. The Analysis of Future Floodplains in New York State Study, funded by the New York State Energy Research and Development Authority, seeks to develop such information. Our effort is focusing on projecting the future footprint of the FEMA floodplain, including identification of the critical area subject to structurally damaging wave action. This work will be accomplished by leveraging the existing National Flood Insurance Program (NFIP) flood hazard information and application of analytical techniques to proximate the future hazard.

More-accurate, detailed modeling of surge and wave processes is costly, time-consuming and difficult to justify when considering the range of uncertainty in sea level rise projections. Recent studies funded by the Federal Emergency Management Agency have shown the changes in probabilistic surge elevations used to define the extent NFIP floodplain remain nearly linear for lower SLR conditions. However, changes in wave effects, which largely influence regulatory Base Flood Elevations (BFEs), do not follow the same linear increase. Separation of these two key flood processes allows for improved calculation of future conditions with a relatively low level of effort.

Our presentation will highlight results of validation of approximate methods for future flood conditions against detailed modeling. Further, we will provide an overview of how these techniques are implemented to provide a cost-effective solution for informing New York State on potential future flood conditions.

DOWNSCALED PROJECTIONS OF EXTREME RAINFALL IN NEW YORK STATE

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Future changes in the frequency and magnitude of extreme precipitation have profound implications for urban and rural development, public infrastructure, watershed management, agriculture, and human health. In consideration of these socioeconomic issues, the Northeast Regional Climate Center (NRCC) is partnering with the New York State Energy Research and Development Authority (NYSERDA) to compare various methods of downscaling global climate model (GCM) output and create extreme rainfall projections

that can be incorporated into climate change adaptation planning. Primary objectives of this study include: 1) evaluation of downscaling method–climate model combinations to assess their ability to replicate present-day rainfall extremes, 2) downscaling of projected rainfall extremes for future time periods, 3) quantification of methodological and climate model uncertainties, and 4) outreach and development of web-based tools to make results accessible to users. At this time, we have completed the first of several candidate downscaling procedures, which involves bias correcting dynamically downscaled GCM output.

Our extreme rainfall projections are based on data from two primary sources: 1) daily precipitation observations from 157 first-order and cooperative observer stations in New York and surrounding areas of adjacent states and Canada and 2) gridded daily precipitation estimates from regional climate models (RCMs) run at 50-km resolution and driven by atmosphere–ocean general circulation models (AOGCMs). The seven RCM simulations are obtained from the North American Regional Climate Change Assessment Program (NARCCAP) and include output for base (1970–1999) and future (2040–2069; A2 emissions scenario) periods. We began our analysis by constructing partial duration series (PDS) of 1-day extreme rainfall events at each station and the nearest RCM grid box for the base period. Recurrence interval rainfall amounts at each station and RCM grid box were then estimated using two statistical fitting approaches. The station-based Beta-P approach employs a maximum likelihood distribution and assumes that the PDS frequency distributions at all stations are statistically independent. The regionalized L-moments approach employs a generalized extreme value distribution and groups stations together based on similarities in the shape and scale parameters of their PDS frequency distributions. In order to convert average precipitation over a grid box to point values of precipitation, we applied areal reduction factors (ARFs) to the RCM recurrence interval rainfall amounts. Next, we used quantile–quantile mapping to calculate the remaining base period biases between station and ARF-adjusted RCM recurrence interval rainfall amounts. Future projections of extreme rainfall at each station were obtained by applying these bias correction factors to the future period ARF-adjusted RCM recurrence interval rainfall amounts.

LOW TEMPERATURES DURING THE COLD SEASON AND HOSPITALIZATIONS DUE TO ACUTE MYOCARDIAL INFARCTION IN NEW YORK STATE, 1991-2004

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The relationship between meteorological factors and acute myocardial infarction (AMI) is not well understood. Few studies have evaluated the effect of cold temperatures on AMI hospitalizations. The objective of this study was to evaluate the effects of winter temperatures on admissions due to AMI and to examine the interactive effects between weather factors and demographics in relation to AMI.

A time-stratified case-crossover design was employed. The study population included hospitalizations from 14 New York State weather regions with a primary diagnosis of AMI during the cold season, 1991-2004. The temperature indicators assigned for each region were apparent daily average temperature (UATavg), which includes relative humidity and wind speed; 3-day moving average UATavg; and extreme temperature, defined as the 10th percentile of UATavg distribution. Exposure odds ratios (OR) and 95% confidence intervals (CI) were calculated using conditional logistic regression after controlling for other weather factors.

UATavg below 35F increased the odds of being hospitalized due to AMI with the strongest effects when UATavg was -15F (OR=1.35, 95%CI: 1.08-1.68) 4-6 days prior to hospitalization. The moving averages and extreme temperature also showed similar associations with AMI for the same 4-6 day lags. Being male, white, 45-74 years old, Medicaid insured, and residing in the Binghamton region increased the odds of AMI hospitalization at UATavg below 30F. Temperatures below the freezing point are associated with AMI hospitalizations 4-6 days later, and certain demographic factors may change the temperature – AMI association.

THE EFFECT OF EXTREME HEAT DURING SUMMER ON BIRTH WEIGHT AMONG TERM BABIES IN NEW YORK STATE, 1991-2006

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The relationship between meteorological factors and low birth weight (LBW) is not well understood. Few studies examined the effect of high ambient temperatures during the warm season on birth weight (BW).

The objective of this study was to assess the effect of extreme heat on BW. Using a case-control study design, cases were defined as LBW (BW<2,500 g) term babies (gestational age > 37 weeks). Controls were normal BW term babies. Cases and controls were born in 10 New York State weather regions between 1991 and 2006. Two heat wave (HW) indicators were assigned for each region: 1) at least 3 consecutive days with maximum temperature 900F or above (HW90) and 2) at least 2 consecutive days with maximum temperature equal or above the 97th percentile of the maximum temperature distribution (HW97). HW frequency and duration were also examined. Exposure odds ratios (OR), linear regression parameter estimates, and 95% confidence intervals (CI) were calculated using logistic regression and linear regression, while controlling for other weather factors, air pollution, and maternal socio-demographic variables.

HW97 showed the strongest and most consistent association with LBW (OR =1.05, 95%CI: 1.01-1.08 for the entire pregnancy, and OR=1.10, 95%CI: 1.05-1.16 for the first trimester). Linear regression parameter estimates showed that HW97 in the 1st trimester was associated with a significant 11.25 g decrease in BW. A similar pattern was observed for HW90 but fewer estimates were statistically significant. No dose-responses for HW frequency or duration were observed. Extreme heat events during pregnancy may be associated with LBW among term babies with the strongest effect if the event occurred in the 1st trimester of pregnancy.

ECOSYSTEMS

AN EXAMINATION OF FISH PRESENCE USING THE RELATIONSHIP BETWEEN BASE CATIONS (BC) AND STRONG ORGANIC ANIONS (RCOOS-) IN WATERS COLLECTED BY THE ADIRONDACK LAKES SURVEY CORPORATION

James E. Dukett, Nathan Houck, Phil Snyder, Sue Capone

Research shows recent decreases in toxic aluminum concentrations are a result of a combination of acid deposition decreases and dissolved organic carbon increases. This is a positive recovery signal, which is a result of policy efforts to reduce acidity from emissions of sulfur dioxide and nitrogen oxides. As Adirondack lakes recover from years of acidification, and toxic aluminum continues to decrease, fishery managers will require additional information to evaluate chemical nutrient status to allow for efficient resource allocation (i.e., fish stocking). An examination of the relationship between base cations (BC) and strong organic anions ($RCOO_s^-$) provides an additional metric to evaluate the chemical recovery status of Adirondack lakes. In this poster, we will show the unique relationship between BC and $RCOO_s^-$ and how it, along with other chemical metrics (i.e., base cation surplus, ANC, toxic Al, and pH), are related to fish presence.

ASSESSING CHANGES IN REGULATING SERVICES AFTER BIOMASS REMOVAL IN THE HUBBARD BROOK EXPERIMENTAL FOREST, USING THE FOREST ECOSYSTEM SERVICES TOOLKIT (FEST).

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The Forest Ecosystem Services Toolkit (FEST) is a collaborative USDA-funded effort to couple long-term ecological data with contextual social information to generate dynamic measures of ecosystem services (ES). Currently in development, FEST will allow users to explore how forest management, climate change, and pollution shape the capacity of forest watersheds to deliver essential and desirable services to human populations at multiple scales. Our initial focus is on regulating services, such as the capacity of forest watersheds to provide high-quality water to meet multiple human needs or the ability of forests to self-regulate growth of biomass for use as timber, energy feedstocks, carbon storage, or wildlife habitat. Ultimately, it will be possible to use FEST outputs to understand trade-offs between ecosystem services (both regulating and provisioning) as well as possible bundling between these services. This will be valuable to regulators and policy-makers hoping to understand how the flow of ecosystem services from forests may change under multiple scenarios of management, land use, climate change, and acid deposition. The objective of this poster is to demonstrate how FEST methodologies and outputs can be used to understand the possible effects of biomass harvesting on regulating services in two stands in the Hubbard Brook Experimental Forest, a whole-tree harvest (WTH) and a reference stand. Whole-tree harvest, in which tree tops and low-quality timber are removed in timber harvest alongside more-valuable wood products, is widely seen as a likely harvesting method where markets exists for both conventional wood products and woody biomass for use in energy production. By comparing the whole-tree harvest to the reference site at Hubbard Brook, it is possible to explore how use of this harvesting

method changes the dynamics of water flow regulation, water quality regulation, and the regulating services associated with forest growth over time. Initial results suggest that impacts of WTH on these services are varied, with effects on water quality and vegetation being more pronounced than those on water flow. Effects on flow/quality, however, disappear within a few years while effects on vegetation are more long-lived.

DRIVERS OF INVERSE DOC-NITRATE LOSS PATTERNS IN FOREST SOILS AND STREAMS

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Nitrate losses from forested catchments vary greatly across sites and over time, with few reliable correlates. Over the last two decades, nitrate concentrations in surface waters have decreased across the northeastern United States and parts of northern Europe. Many hypotheses have been proposed to explain this decrease, but the cause remains unclear. One control may be associated with increasing abundance of dissolved organic carbon (DOC), which in turn may be a result of soil recovery from acidification. One of the few recurring patterns of nitrate loss is the negative nonlinear relationship that occurs regularly between surface water nitrate and dissolved organic carbon (DOC) concentrations: that is, nitrate declines sharply as DOC concentrations increase, and high nitrate levels occur only at low DOC concentrations. Several hypotheses have been proposed to explain this pattern, but its cause has remained speculative. It is likely to be driven by C- or N-limitation of biological processes such as assimilation or denitrification, but the identity of which biological process or where it occurs in the landscape is not known. We examined whether DOC and nitrate are both driven by soil C content, at scales of both soil blocks and across catchments, by measuring soil, soil extract, and surface water chemistry across nine catchments selected from long-term monitoring networks in the Catskill and Adirondack Mountains. We measured soil C and N status and solution nitrate, DOC, bioavailable DOC (bDOC), and isotopic composition (13C-DOC, 15N- and 18O-NO3) to examine whether variation in stocks of soil C partly controls DOC and nitrate loss from forested catchments in New York State. In addition, we conducted soil core leaching experiments to examine the role of acidification and recovery in driving the net production of DOC and NO3- from soils. Short-term extractions showed that acid extracts released less DOC than higher-pH extracts. Long-term leaching showed that that acidified cores released more bio-available DOC than cores with experimentally increased pH. The catchment-scale measurements showed that surface soil C and C:N ratio together determine soil production of DOC and nitrate, reflecting assimilative demand for N by heterotrophic microbes. Yet, they also show that these processes do not produce the inverse DOC-NO3 curve observed at the catchment scale. Rather, catchment-scale DOC-nitrate patterns are more likely to be governed by the balance between excess nitrate production and its bDOC-mediated loss to denitrification.

LIMING TO ACCELERATE THE RECOVERY OF ACIDIFIED ECOSYSTEMS: A CASE STUDY IN THE ADIRONDACK MOUNTAINS OF NEW YORK

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The Adirondack region of New York State is sensitive to acidic deposition, and widespread effects on aquatic and terrestrial ecosystems have been demonstrated. As of the mid-1980s, about 25% of Adirondack lakes were too acidic (ANC<0 μeq/L, pH<5.0) to support a healthy fish community, and brook trout were believed to be extirpated from many lakes. Since that time, precipitation acidity has decreased as the Clean Air Act and its amendments were implemented, and emissions of SO2 and other acid precursors have declined. As a result of decreased acidic deposition, Adirondack lakes have begun to recover; widespread decreases in SO42- and Al concentrations along with increases in pH and ANC have been reported. Notably, some lakes with ANC values ≤0 μeq/L have now increased to ≥0 μeq/L, indicating conditions favorable for increased diversity of the aquatic biological community. Declines in lake acidity to date, however, have been less than those of atmospheric deposition, and limited biological data suggest a slow recovery to a pre-acidification community, hindered partly by the slow pace of recovery of soil exchangeable Ca2+ previously lost to acid leaching. As a means of accelerating aquatic and terrestrial ecosystem recovery, we are studying the effects of stream and watershed liming in several tributaries to Honnedaga Lake in the southwestern Adirondacks. This lake was acidified to summer pH values <5.2 in the 1960s through the 1980s, but recent values have risen to ~5.5, accompanied by decreases in Al concentrations. The lake and its tributaries contain a heritage strain of brook trout whose numbers were greatly diminished as acidification progressed. While the population density of these trout has increased in recent years in parallel with improvements in water quality, numbers remain low due to the sluggish recovery. Many of the lake tributaries remain chronically or episodically acidic, limiting recovery of brook trout populations. Liming is being studied as a method for improving brook trout recruitment in key lake tributaries with an aim of

providing guidance for future liming activities that may improve fisheries management in the Adirondack region. Human intervention in the process of acidification recovery through liming, however, may have unintended consequences such as increases in DOC concentrations, which may lead to increased Hg bioaccumulation in aquatic biota. Therefore, we are also studying the consequences of stream and watershed liming on Hg bioaccumulation. The most recent results of this investigation will be presented.

MERCURY LEVELS IN SMALL FISH FROM SENECA LAKE TRIBUTARIES

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Mercury (Hg) is a common pollutant that bioaccumulates in aquatic systems, an issue of significant importance since the ingestion of fish with high methyl Hg levels can result in a number of deleterious health effects in humans and other organisms. These include, but are not limited to, toxicological effects such as diminished neurological performance. Since virtually all Hg present in fish at the top of the food web is in the methylated form, total Hg measurements are often used as a proxy for methyl Hg. Determining Hg levels of fish in streams, as well as lakes, is important since both tributaries and watersheds are known locations of methyl Hg production and bioaccumulation. Since 2011, small fish have been collected on an annual basis in approximately ten different Seneca Lake tributaries and analyzed for total Hg using a Milestone Direct Mercury Analyzer at the Finger Lakes Institute. The target fish for this study is the blacknose dace, a small ubiquitous omnivorous fish, found in all of the sampled Seneca Lake tributaries and throughout New York State. Large differences in blacknose dace Hg concentrations have been observed among the sampled Seneca Lake watershed tributaries, both spatially and temporally. However, Hg levels in tributary blacknose dace are on average below those published for yellow perch, smallmouth bass, and lake trout sampled from Seneca Lake. This is expected since the blacknose dace occupies a lower trophic position than those fish species. In general, higher total Hg concentrations were observed in sampled tributaries at the northern and southern ends of the watershed. Though most fish Hg concentrations remained fairly consistent from year to year, fish sampled from Hector Falls Creek subwatershed have shown a marked increase in Hg levels compared to 2011. Based on these preliminary analyses, it appears that the blacknose dace is an excellent indicator species for observing temporal and spatial Hg trends since they are found at every sampled site, have a small home range, show significant differences in Hg concentrations among sites, and are eaten by larger fish such as trout. Findings from this work will contribute to the long-term assessment of the health of Finger Lakes ecosystems and aid in the communication of information about consumption of fish caught in the Finger Lakes with regard to Hg concentrations.

MONITORING OF AN ADIRONDACK ECOSYSTEM: IMPACTS OF ACIDIC AND MERCURY DEPOSITION AND CLIMATE CHANGE ON WATERSHEDS

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The Huntington Forest (HF) has participated in the National Atmospheric Deposition Program (NADP) and the National Trends Network (NTN) since Oct. 31, 1978. The HF has also been part of the Mercury Deposition Network (MDN) since December 10, 1999. The HF has also been a site for various regional biogeochemical studies, including being one of the original Adirondack Long-Term Monitoring (ALTM) lakes. In May 2002, a Clean Air Status and Trends Network (CASTNET) site was installed. CASTNET is operated by the U.S. E.P.A. and provides atmospheric data on the dry deposition component of total acidic deposition, ground-level ozone, and other forms of atmospheric pollution. The Arbutus Lake Watershed has been gauged at the lake outlet since October 1991 with a V-notch weir. The 130 ha Archer Creek Catchment drains into Arbutus Lake. This catchment has been monitored since 1994 using an H-flume equipped with automated discharge logging and sample collection system. Water chemistry samples are taken weekly except during storm events, when more frequent sampling is done. Various plots and subcatchments, including both upland and wetland sites, have been intensively instrumented since 1994. On November 11, 2007, HF became a participant in the AMNet monitoring network with the site operation by Clarkson University. SUNY-ESF will be taking over operation of this AMNet site this year. The AMNet determinations include atmospheric mercury concentrations of gaseous oxidized, particulate-bound, and elemental mercury. The HF has also been a participant in the Ammonia Monitoring-Project (AMoN). This coming fall the HF will become a participant in the Mercury Litter network using the USGS protocol. Results from the concentration of flux of mercury in leaf litter provide important information on mercury deposition to forests. Beginning in 2004 we developed a "state of the art system" for obtaining real-time data in the Arbutus Watershed. The system includes radio transmission of discharge (Arbutus Outlet, Arbutus Inlet, Subwatershed 14, and Subwatershed 15), groundwater height in wells, and various meteorological parameters. Access to real-time and archived biogeochemical, hydrological, and meteorological data as well as real-time images from the watershed are available

on the web. We will present examples of measurements of atmospheric deposition, meteorology, and watershed biogeochemistry. We will use examples of some of these results to show how these data can be utilized in evaluating long-term trends as well as the evaluation of individual storm events in helping understanding important processes related to atmospheric deposition and climate change.

NEW INTERNATIONAL REGULATIONS ON MERCURY: WILL THEY CHANGE THE COURSE?

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After four years of negotiations, the international community agreed on the provisions of a global mercury treaty that will be known as Minamata Convention. This is the first ever agreement that will regulate the use, movement, and release of a single element. The international action was warranted because there was sufficient scientific evidence that mercury and mercury compounds have a significant adverse impact on humans and wildlife, even in remote regions lacking direct industrial inputs.

This paper will review some of the major provisions in the agreement related to anthropogenic mercury emissions and releases to land and water, artisanal and small-scale gold mining, large-scale mining operations, the production and export of mercury and mercury-containing products, as well as proposed actions for sustainable storage and management of mercury-impacted sites. Background scientific information on mercury fate and transport will be presented in the context of both local and global effects. Relevance to current U.S. regulations and the effectiveness of the new agreement will be discussed.

REFINEMENTS TO THE ADIRONDACK LONG TERM MONITORING (ALTM) LAKES SAMPLING PROGRAM

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The New York State Department of Environmental Conservation has been monitoring surface water acidification in the Adirondacks for over 30 years. In more recent years, the monitoring has been conducted by Adirondack Lakes Survey Corporation. The recent significant chemical improvements in several ALTM lakes has continued to advise air policy and prompted reviews of the efficiencies of the existing schedules. Furthermore, new knowledge about the sensitivity of streams, the behavior of mercury and climate-related influences provide additional reasons to re-examine the program. As a follow-up to the NYSERDA sponsored study by State University of New York College of Environmental Science and Forestry, DAR conducted additional assessments of ALTM lakes with a particular focus on preserving sampling integrity over a range of key chemical parameters (nitrate, acid neutralizing capacity, pH and dissolved organic carbon), watershed characteristics (drainage/seepage; complex/simply hydrology; wetlands), and management (liming/stocking) considerations. We present the results of our assessments and the rationale for the refinements made to the ALTM lake/watershed sampling locations and frequencies for the years beginning in 2014.

THE EFFECT OF PH AND CALCIUM ON DECOMPOSITION AND SOIL MICROBIAL COMMUNITY COMPOSITION

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Liming ($CaCO_3$) has been suggested as a way to manage and accelerate the recovery of forest ecosystems that have been severely affected by acid deposition. The effect of liming on belowground soil processes is still poorly understood. A recent study of a watershed liming experiment at the Woods Lake catchment, NY found that 20 years after the lime addition, a large stock of organic matter had accumulated in the upper horizons of the soil and rates of decomposition were suppressed. The responses were contrary to expectations that lime additions would increase decomposition. This decrease in decomposition could be the result of changes in size, activity and/or behavior of the decomposer communities in the treated plots. Alternatively, liming may alter the physical stabilization of organic matter, making it unavailable for microbial decomposition. I propose to investigate the mechanisms that lead to organic matter accumulation in limed soils. My project will assess whether reduced rates of litter decomposition, microbial enzyme activity and availability of carbon to microbes can explain the suppression of decomposition in limed soils. Litter decomposition will be measured with a field litterbag study, and microbial biomass and enzyme activity will be measured with standard laboratory assays.

Potential shifts in the soil microbial community composition in treated soils will be assessed using qPCR. It is anticipated that the results of the litter decomposition study and microbial enzyme and community analyses will potentially provide an explanation for these lower decomposition rates. The results of this project may help identify the causes of watershed scale changes observed in the Woods Lake catchment where liming has altered rates of organic matter decomposition in the long run.

Crosscutting

HUDSON RIVER ENVIRONMENTAL CONDITIONS OBSERVING SYSTEM (HUDSON RIVER ECOS)

Gavin Lemley

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The Hudson River Environmental Conditions Observing System (Hudson River ECOS) was established in 2008 to provide high-frequency, real-time environmental data that are geographically distributed throughout the Hudson River Estuary and Mohawk River. The system consists of several water quality and weather stations that use remote telemetry to transmit data, which is reported in near-real-time to a public website (www.hrecos.org) where users can plot graphs and download time series. Stations are operated and funded by a consortium of partner institutions from the government and research community. Hudson River ECOS builds upon existing monitoring and observing activities on the Hudson River Estuary, including NOAA's National Estuarine Research Reserve System-Wide Monitoring Program (SWMP), NYSDEC Rotating Integrated Basin Studies, USGS monitoring efforts, and modeling and monitoring efforts undertaken by Stevens Institute of Technology in the NY-NJ Harbor. The goals of Hudson River ECOS are to provide baseline monitoring data necessary for applied research and modeling, improve the capacity of research entities to understand the ecosystem and manage estuarine resources, provide policy makers with timely data products to guide decision making, support the use of real-time data in educational settings, and provide information for planning recreational activities (boating, kayaking, fishing, etc.). Hudson River ECOS is a rapidly growing network, with one or more stations being established each year since its inception.

THE NORTHEAST REGIONAL EARTH SYSTEM MODEL: SCIENCE TO SUPPORT REGIONAL DECISION MAKING

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The Northeast has a rich history of strategic environmental transformations: from deforestation and land clearing, to industrialization and urbanization, to post-industrial, mega-city growth. The closely woven human-environment system of the region will continue and, arguably, be more difficult to manage in the 21st Century due to the impacts of global climate change. In the context of climate change and long term ecosystem response times, environmental management decisions made today will reverberate through the remainder of this century.

Since the atmosphere, land and aquatic ecosystems are closely linked through biogeochemical cycles and fluxes of water and energy, changes to any one of these systems may lead to unintended feedbacks and consequences. Yet, scientific tools to assist decision makers in understanding human-environment systems over the regional domain and decadal timescales are currently limited. To address this need, we are developing a Northeast Regional Earth System Model (NE-RESM) to better understand the interaction between the region's atmosphere, waters and land ecosystems and their interaction with regional infrastructure and energy systems.

We have begun a participatory scenario design process, which will be used to support NE-RESM modeling experiments that provide insight on the implications of regional environmental management decisions. In collaboration with small panels of stakeholders, we have developed 4 regional storylines: "*Business as usual*," "*Eco-Preservation*," "*Eco-Innovation*," and "*Deregulation*." We currently seek inputs from the regional stakeholder community to further develop these storylines and to provide guidance as they are translated into quantitative modeling scenarios.