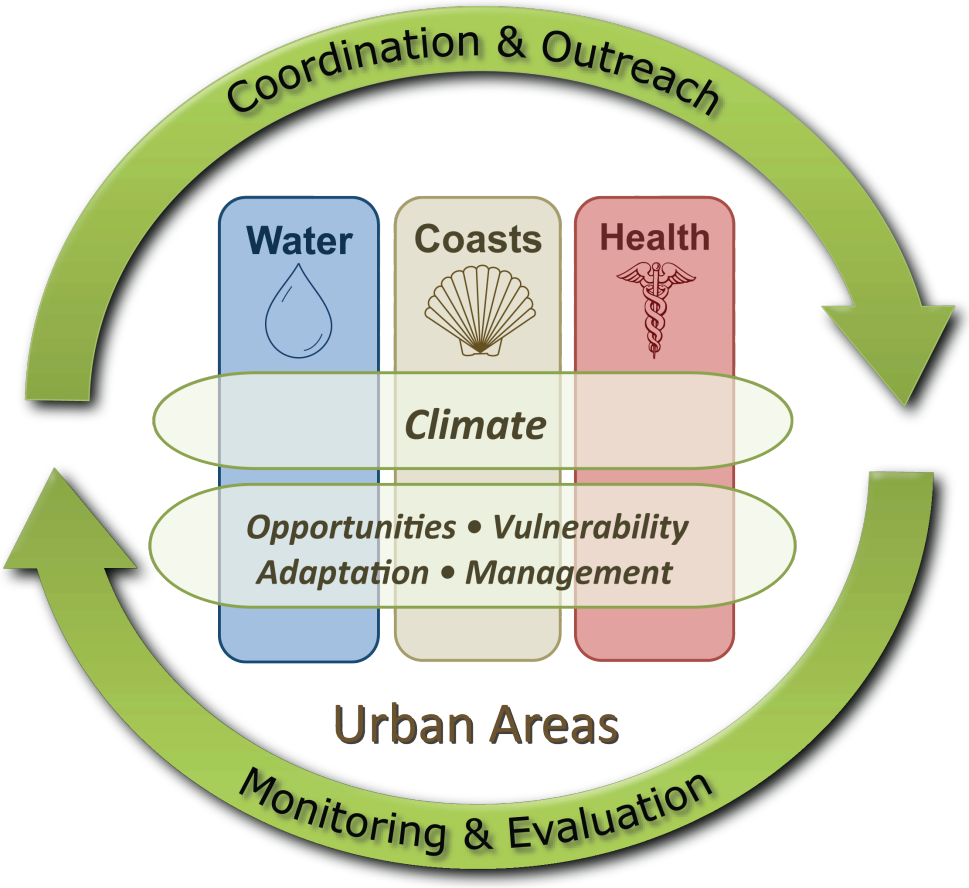
Consortium for Climate Risk in the Urban Northeast

Research Highlights, October 2010 - April 2011

CCRUN



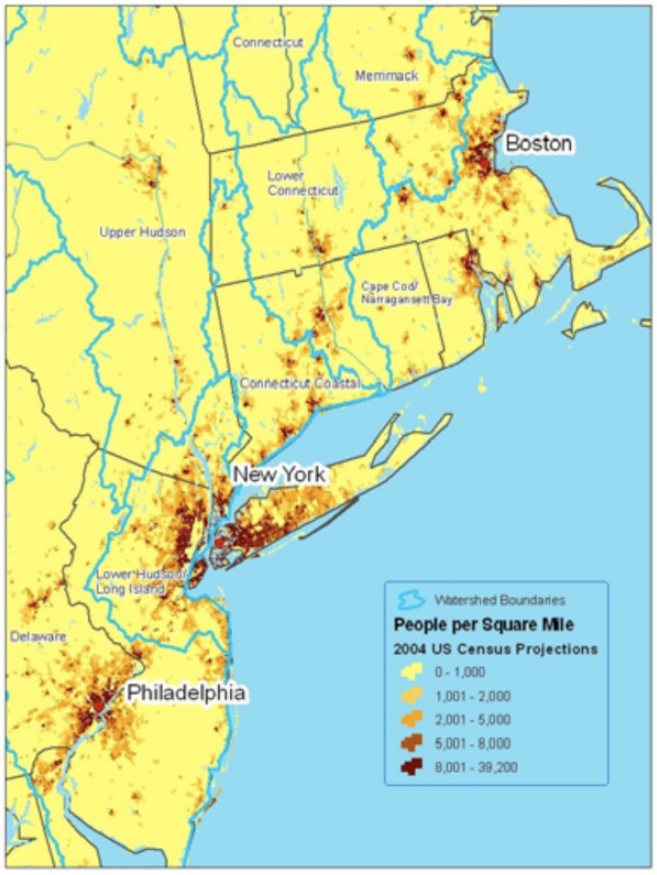
CCRUN's Mission

To conduct stakeholder-driven research that reduces climate-related vulnerability and advances opportunities for adaptation in the urban Northeast

Introducing CCRUN

The Consortium for Climate Risk in the Urban Northeast, or CCRUN, is one of five new teams funded in October 2010 under NOAA's Regional Integrated Sciences and Assessments (RISA) program to serve stakeholder needs in assessing and managing risks from climate variability and change. It is currently also the only RISA team with a principal focus on climate change adaptation in urban settings. CCRUN is structured as a multi-modal network that covers the relevant portions of Massachusetts, Rhode Island, Connecticut, New York, New Jersey and Pennsylvania, so that local needs for targeted climate-risk information can be served in a coordinated way.

CCRUN is designed to address the complex challenges that are associated with densely populated, highly interconnected urban areas, including such as: urban heat island effects; poor air quality; intense coastal development, and multifunctional settlement along inland waterways; complex overlapping institutional jurisdictions; integrated infrastructure systems; and highly diverse, and in some cases, fragile socio-economic communities. These challenges can best be addressed by the stakeholder-driven interdisciplinary approach taken by the CCRUN RISA team. As an important added benefit, the research accomplishments and lessons learned through stakeholder engagement will provide a foundation for managing climate risks in other urban areas in the United States.



CCRUN encompasses the Philadelphia-New York-Boston urban corridor. The major metro areas of CCRUN are among the most populous and densely populated regions in the United States, as of the 2000 U.S. Census.

CCRUN's initial projects are focused in three broad sectors: Water, Coasts, and Health. Research in each of these sectors is linked through the cross-cutting themes of climate change and community vulnerability, the latter of which is especially important in considerations of environmental justice and equity. CCRUN's stakeholder-driven approach to research can therefore support investigations of the impacts of a changing climate, population growth, and urban and economic policies on the social, racial and ethnic dimensions of livelihoods and of communities in the urban Northeast. Disadvantaged socio-economic groups have been particularly underserved in the area of climate change, and one of CCRUN's long-term goals is the building of adaptive capacity among such groups to current and future climate extremes.

The CCRUN Team

The team is comprised of investigators, research & support staff, and graduate students from five institutions across the CCRUN project area: Columbia University (CU), the University of Massachusetts-Amherst (UMass), City College of the City University of New York (CCNY), Stevens Institute of Technology (Stevens), and Drexel University (Drexel).

Lead Investigators, Principal Sectors: Alan Blumberg (Stevens), Patrick Kinney (CU), Richard Palmer (UMass)

Lead Investigators, Cross-Cutting Themes: Yochanan Kushnir (CU), Shiv Someshwar (CU)

Research Coordinator: Radley Horton (CU)

Project Manager: Linda Sohl (CU)

Investigators: Mark Arend (CCNY), Amy Auchincloss (Drexel), Mark Becker (CU), Ray Bradley (UMass), Casey Brown (UMass), Robert Chen (CU), Naresh Devineni (CU), Lisa Goddard (CU), Vivien Gornitz (CU), Patrick Gurian (Drexel), Charles Haas (Drexel), Reza Khanbilvardi (CCNY), Upmanu Lall (CU), Malgosia Madajewicz (CU), Franco Montalto (Drexel), Philip Orton (Stevens), Julie Pullen (Stevens), Cynthia Rosenzweig (NASA-GISS/CU), Sabrina Spatari (Drexel), Brian Vant-Hull (CCNY)

Research & Support Staff: Dan Bader (CU), Nickitas Georgas (Stevens), Adam Greeley (CU), Annie Gerard (CU), Julia Morrison (CU), Marie-Aude Pradal (Stevens)

Graduate Students: Kelcy Adamec (UMass), Elizabeth DeVilbiss (Drexel), Kimberly DiGiovanni (Drexel), Elisaveta Petkova (CU), Jessica Pica (UMass), Brian Pitta (UMass), Mayu Sasaki (CU), Maria Raquel Catalano De Sousa (Drexel), Alex Waldman (Drexel), Ziwen Yu (Drexel)

Research Affiliates: Paul Block (CU), Kathleen Callahan (CU), Suzana Carmaga (CU), Mark Cane (CU), Edward Cook (CU), Stuart Gaffin (CU), Christian Hunold (Drexel), Scott Knowles (Drexel), David Major (CU), Rouzbeh Nazari (CCNY), Mira Olsen (Drexel), Neil Pederson (CU), Anu Pradhan (Drexel), Andrew Robertson (CU), Richard Seager (CU), Mimi Sheller (Drexel), Jin Wen (Drexel), Steve Zebiak (CU), Jianting Zhang (CCNY)

Other Collaborators: Timothy Hall (NASA-GISS), Tiantian Li (China Centers for Disease Control), Alex Ruane (NASA-GISS)

Columbia University in the City of New York

Stevens Institute of Technology — The Innovation University

University of Massachusetts Amherst

Drexel University

the City College of New York

Stakeholders and Partners

A & D Hydro, Inc.
Alternatives for Community and Environment (ACE)
American Red Cross of Greater New York
American Water Company
Appalachian Mountain Club
Ashburnham (MA) Department of Public Works
Bear Swamp Power Company, LLC
Boston Public Health Commission
Brattleboro (VT) Water Department
Bristol (CT) Water Department
Brookfield Renewable Power, Inc.
Bucks County (PA) Water & Sewer Authority
Burlington (MA) Water Department
Canaan (NH) Water Department
Chester (PA) Water Authority
Chicopee (MA) Water Department
Clean Air Council
Connecticut Department of Environmental Protection/Inland Water Resources Division
Connecticut River Watershed Council
Connecticut Water
Dalton Hydro, LLC
Delaware River Basin Commission
Delaware Valley Green Building Council
Delaware Valley Regional Planning Commission/Office of Energy and Climate Change Initiatives
Dorchester (MA) Environmental Health Coalition
East Hampton (CT) Water and Sewer Commission
Environmental Protection Agency
Fairmount Park Commission
Farmington River Power Co.
Fitchburg (MA) Public Works Department/Water Division
Green Mountain Power
Harvard University Graduate School of Design
Holyoke (MA) Gas and Electric Department
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Keene (NH) Public Works Department/Water Division
L.S. Starrett Co.
Massachusetts Department of Conservation and Recreation
Massachusetts Department of Environmental Protection/ Water, Wastewater, and Wetlands
Massachusetts Department of Fish and Game
Massachusetts Executive Office of Energy and Environmental Affairs
Massachusetts Water Resources Authority
Metropolitan District of Connecticut
Monson (MA) Water & Sewer Department
Montgomery County (PA) Advisory Committee on Climate Change
National Grid
National Park Service, Partnership Wild and Scenic Rivers/ Farmington River, CT
National Park Service, Partnership Wild and Scenic Rivers/ Westfield River, MA
The Nature Conservancy
New Britain (CT) Water Department
New England Interstate Water Pollution Control Commission
New Hampshire Department of Environmental Services
New Hampshire Rivers Council
New York City Department of Health and Mental Hygiene
New York City Department of Environmental Protection/ Bureau of Water Supply
New York City Department of Environmental Protection/ Environmental Planning and Analysis
New York City Office of Long-Term Planning and Sustainability
North American Energy Alliance, LLC
North Brookfield (MA) Water Department
Palmer (MA) Water Department
Pennsylvania Department of Conservation and Natural Resources
Pennsylvania Department of Environmental Protection/ Climate Change Advisory Committee
Pennsylvania Environmental Council
Philadelphia City Planning Commission
Philadelphia Department of Public Health/Air Management Services Division
Philadelphia Department of Public Health/Environmental Health Services Division
Philadelphia Department of Streets
Philadelphia Energy Coordinating Agency
Philadelphia Industrial Development Corporation
Philadelphia Mayor's Office of Sustainability
Philadelphia Municipal Energy Office
Philadelphia Office of Emergency Management
Philadelphia Water Department
Philadelphia Parks & Recreation
Rivers Alliance of Connecticut
Springfield (MA) Water and Sewer Commission
Stratford (CT) Department of Public Works/Water Pollution Control
TransCanada
Turners Falls Hydro, LLC
US Army Corps of Engineers
University of Connecticut
Vermont Agency of Natural Resources
Vermont Department of Environmental Conservation/River Management Section
Vermont Department of Environmental Conservation/Water Quality Division
Vermont Department of Fish and Wildlife
Vermont Natural Resources Board
Vermont Natural Resources Council
West Harlem Environmental Action Group
Westfield (MA) Water Resources Department
Williamsburg (MA) Water and Sewer Commission
Women's Health and Environmental Network

Work in Progress

As CCRUN has only recently been established, initial activity within the CCRUN team has been focused heavily upon development of an internal framework for collaboration, development of collaborative proposals, and introductions to stakeholders who will provide the impetus for future projects. However, CCRUN team members are also engaged in ongoing research that fulfills our RISA mission and will serve as part of the foundation for future CCRUN work.

Examples of CCRUN's activities thus far are described below according to sector or cross-cutting theme: water (availability, quality and management); coasts (management and storm surge hazards); public health (effects of heat, air & water pollution); climate (including statistical analyses and model projections); and vulnerability/evaluation.

Sector: Water

Project: Evaluating reservoir operations and the impacts of climate change in the Connecticut River Basin

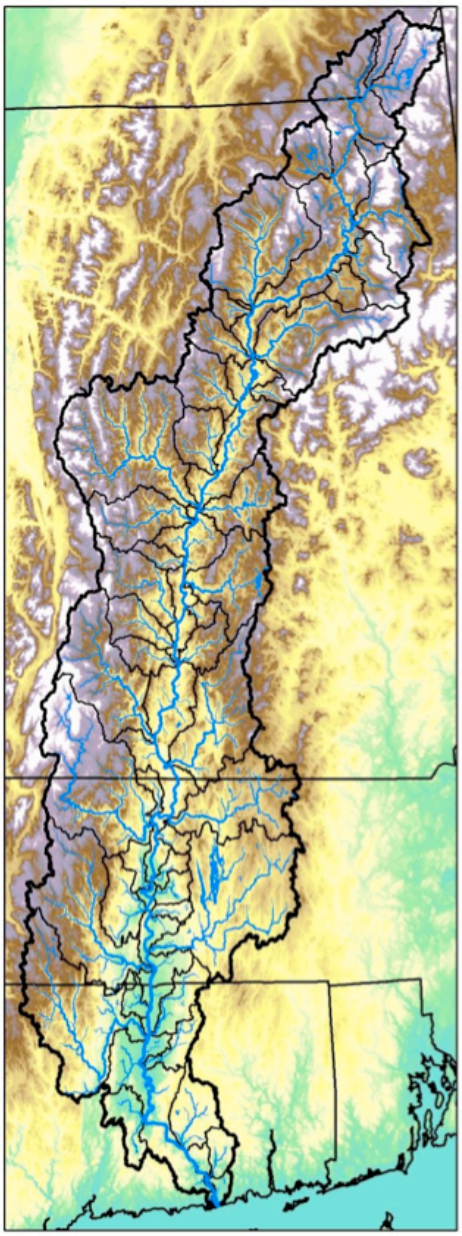
Investigators: Richard Palmer, Casey Brown, Jessica Pica, Kelcy Adamec, Brian Pitta

Abstract: The Connecticut River Basin is the principal water source for communities in portions of Vermont, New Hampshire, central Massachusetts and central Connecticut, with over 70 major dams and reservoirs in operation to help control the water supply. This project will provide The Nature Conservancy, the US Army Corps of Engineers and other stakeholders with climate-informed guidance for current and future dam operations, and illustrate the potential trade-offs between policies that optimize one or more of services provided by the systems' operations. Downscaled data from climate model projections, fed into hydrology models, is used to construct informed streamflow forecasts; these in turn support a reservoir management model that enhances the biological community supported by the river, and existing infrastructural services including flood control, water supply, recreation and hydropower generation. This project also involves the development of decision support tools to guide river operations and to facilitate stakeholder involvement. Workshops are held to gather information about stakeholder requirements for the basin, such as ecological flow targets and dam operations.

Stakeholders: Environmental Protection Agency; Metropolitan District of Connecticut; The Nature Conservancy; Massachusetts Department of Fish and Game; US Army Corps of Engineers; Massachusetts Executive Office of Energy and Environmental Affairs; Brookfield Renewable Power, Inc.; TransCanada; New Britain (CT) Water Department; Springfield (MA) Water and Sewer Commission; University of Connecticut; Vermont Department of Environmental Conservation/River Management Section; Vermont Department of Environmental Conservation/Water Quality Division; New England Interstate Water Pollution Control Commission; New Hampshire Department of Environmental Services; Massachusetts Department of Conservation and Recreation; Connecticut Department of Environmental Protection/Inland Water Resources Division; New Hampshire Rivers Council; Massachusetts Department of Environmental Protection/Water, Wastewater, and

Wetlands; Vermont Agency of Natural Resources; Vermont Natural Resources Board; Vermont Natural Resources Council; Connecticut River Watershed Council; Turners Falls Hydro, LLC; North Brookfield (MA) Water Department; Appalachian Mountain Club; Connecticut Water; Fitchburg (MA) Public Works Department/Water Division; National Park Service, Partnership Wild and Scenic Rivers/Farmington River, CT; National Park Service, Partnership Wild and Scenic Rivers/ Westfield River, MA; Dalton Hydro; LLC; North American Energy Alliance, LLC; Vermont Department of Fish and Wildlife; River Alliance of Connecticut; Bear Swamp Power Company; LLC.; Holyoke (MA) Gas and Electric Department; Ashburnham (MA) Department of Public Works; Farmington River Power Co.; L.S. Starrett Co.; A & D Hydro, Inc.; Green Mountain Power; Brattleboro (VT) Water Department; East Hampton (CT) Water and Sewer Commission; Chicopee (MA) Water Department; Williamsburg (MA) Water and Sewer Commission; Westfield (MA) Water Resources Department; Palmer (MA) Water Department; Monson (MA) Water & Sewer Department; Stratford (CT) Department of Public Works/Water Pollution Control; Bristol (CT) Water Department; Canaan (NH) Water Department; Keene (NH) Public Works Department/Water Division; Burlington (MA) Water Department

Leveraged funding: The Nature Conservancy and the US Army Corps of Engineers



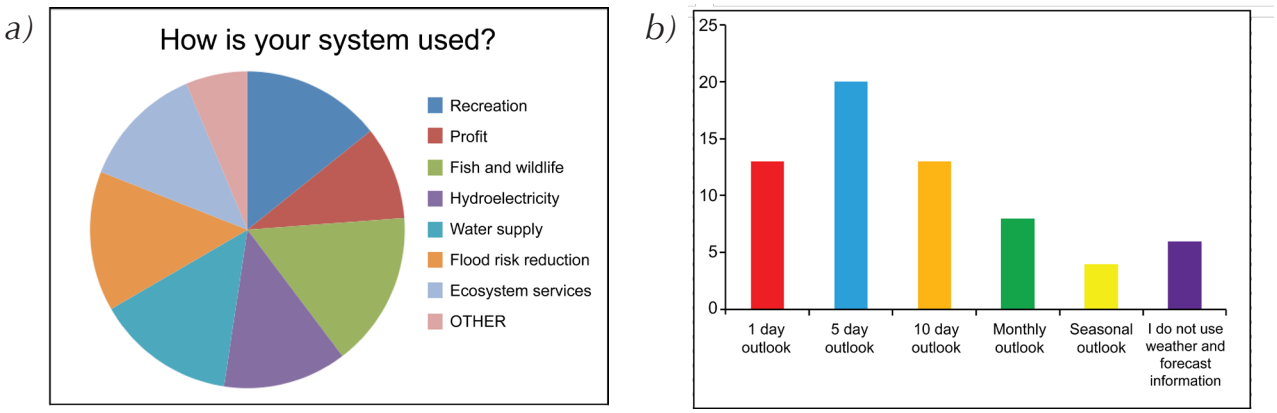
The Connecticut River Basin (outlined in black) provides water to some 2.3 million people, and about 70% of the freshwater input to Long Island Sound (Connecticut River Watershed Council, 2010).

Project: Collaborative development of climate information for the Connecticut River Basin using Shared Vision Forecasting

Investigators: Casey Brown, Richard Palmer

Abstract: The spread of technical information and practices is often lost in communication when transferred between a source and the end users. This research seeks to bridge the gap between climate information and its users, specifically in water management and operations, through the use of Shared Vision Forecasting and the diffusion of innovations framework, to promote the adoption of forecasting techniques. Through a series of workshops with water managers in the Connecticut River Basin, this research will establish a climate knowledge network and an information baseline of the current use of climate information and forecasting in water management decision-making. Better understanding of how managers adopt new forecast techniques and climate data will provide the feedback needed to improve forecasting and climate information.

Stakeholders: See list for the Connecticut River Basin project described previously.



Sample results from a survey of Connecticut River Basin stakeholders, indicating a) how their local water system is used, and b) what forecast time horizons are most useful for decision-making at their level.

Project: Impacts of climate change on the Massachusetts Water Resources Authority water supply system

Investigators: Richard Palmer, Casey Brown, Jessica Pica

Abstract: An on-going study of the water supply system of the Massachusetts Water Resources Authority (MWRA) includes the watershed area for the City of Boston. Activities involved in this study include the creation of downscaled data from climate model projections, and hydrological model studies to explore the range of the potential impacts of climate change on the watershed. The streamflow projections produced by the hydrology model will then be input into a water supply system simulation model to help inform decision management for possible climate change scenarios. The ABCD hydrology model incorporated into the water supply system simulation model will also be validated separately against historic data to improve confidence in the overall results. This project also involves the development of decision support tools to guide water supply operations and to facilitate stakeholder involvement.

Stakeholders: Massachusetts Water Resources Authority

Project: Climate information for water harvesting and re-use strategies in urban settings

Investigators: Franco Montalto, Charles Haas, Sabrina Spatari, Patrick Gurian, Alex Waldman, Kimberly DiGiovanni, Maria Raquel Catalano de Sousa, Ziwen Yu

Abstract: This project explores the impact of changes to precipitation and temperature on the hydrology of urban spaces, and the terrestrial and aquatic ecosystems connected to them directly or indirectly through infrastructure. Specifically, we are investigating relationship between climatological conditions and water/wastewater/stormwater infrastructure, with a focus on

impacts of climate conditions on water and wastewater treatment plant performance, and the use of various green infrastructure (GI) strategies as a climate change adaptation strategy (through its role in reducing the energy and GHG emissions associated with less stormwater, and facilitating urban evapotranspiration). Using life cycle assessment (LCA) tools, we are also investigating the environmental efficiency of green infrastructure technologies to verify consistency with expected environmental performance under different climate conditions, in order to quantify the payback time required to compensate for the environmental costs related to the material required for GI installation.

Initial results: A preliminary analysis (Spatari et al., 2011 in press) suggests that a Low Impact Development (LID) green infrastructure (GI) strategy can help reduce annual energy consumption and avoid greenhouse gas emissions. On the scale of a city block, the annual savings are small compared to the energy and greenhouse gas intensity of the LID materials, resulting in slow environmental payback times. However, if LID strategies are implemented throughout an urban watershed, they can make an important contribution to energy cost savings at municipal water pollution control facilities, and help reduce the city's carbon footprint.

Stakeholders: Philadelphia Water Department; American Water Company; Chester (PA) Water Authority; Bucks County (PA) Water & Sewer Authority; Delaware Valley Regional Planning Commission/Office of Energy and Climate Change Initiatives; Philadelphia Mayor's Office of Sustainability; Pennsylvania Department of Environmental Protection/Climate Change Advisory Committee; Delaware Valley Green Building Council; Fairmount Park Commission; Montgomery County (PA) Advisory Committee on Climate Change; Philadelphia Energy Coordinating Agency; Philadelphia City Planning Commission; Philadelphia Department of Public Health/Air Management Services; Philadelphia Industrial Development Corporation; Philadelphia Municipal Energy Office; Philadelphia Department of Streets; Philadelphia Parks & Recreation; Clean Air Council; Pennsylvania Department of Environmental Protection; Pennsylvania Department of Conservation and Natural Resources; Pennsylvania Environmental Council

Leveraged funding: NSF Graduate Student Fellowship (DiGiovanni), Drexel's Graduate Assistance in Areas of National Need (GAANN) Program

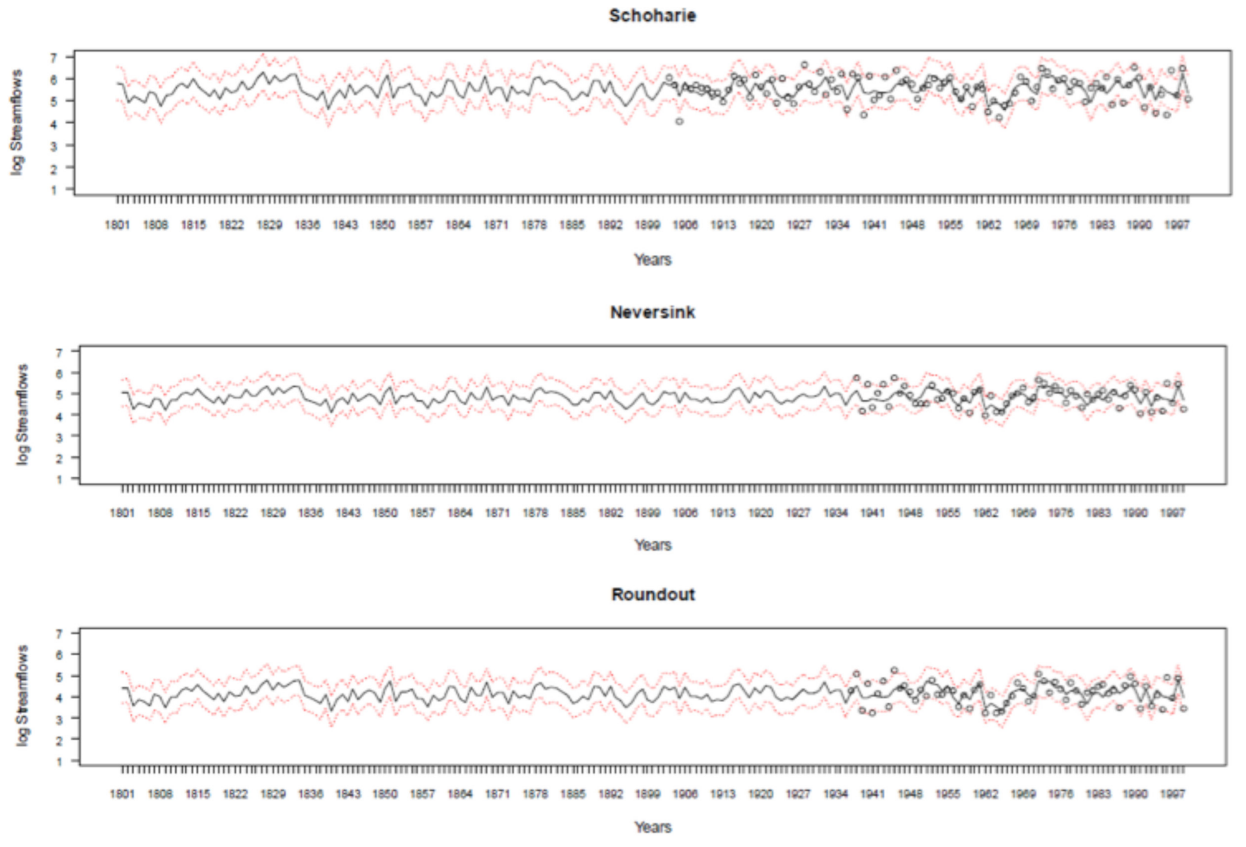
Replacing gray, centralized and monofunctional wastewater and stormwater infrastructure (left) with green, decentralized and multifunctional infrastructure (right) improves urban ecohydrology, ecology, and overall environmental quality.

Project: Delaware River streamflow reconstruction using tree rings

Investigators: Naresh Devineni, Upmanu Lall, Neil Pederson, Edward Cook

Abstract: The upper Delaware River Basin System (DRB) is one of the largest water supply systems for the City of New York, supplying nearly 50% of its capacity for the consumptive water use for New York City. Quantitative evaluations of reservoir systems such as the DRB are typically based on historical (short-term) observations that may not fully represent the magnitude and frequency of extreme droughts for the river basin system, and that may under- or overstate the length and severity of the longest drought of record. Reconstruction of the streamflow records, using proxy information such as tree ring data, can provide crucial information for robust long-term planning. To reduce uncertainties for these streamflow reconstructions, we have developed a full probability model (Hierarchical Bayesian Regression, or HRB) that specifies the joint probability distribution for all the observable and unobservable quantities. The risk of droughts of different severity and duration (as perceived from the reconstructed flows) can be assessed statistically through Monte Carlo simulations, relative to current and projected water demand patterns. As a result, reservoir operating rules could be improved, with a better understanding of long-term risks ,and methods to detect changes in climate/streamflow regime.

Stakeholders: Delaware River Basin Commission; New York City Department of Environmental Protection/Bureau of Water Supply



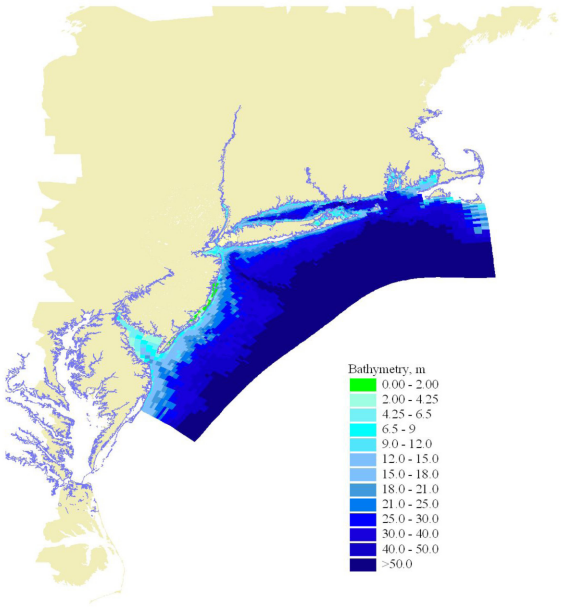
Reconstructed streamflow along three rivers in the Delaware River Basin for the years 1801-1997, using our new HRB model. The solid gray median line represents the average reconstructed flow; observations going back through 1906 are shown as open circles.

Sector: Coasts

Project: Accurate extra-tropical storm surge modeling: The influence of model dimensionality, freshwater inputs, tides, and model grid area

Investigators: Alan Blumberg, Julie Pullen, Philip Orton, Nickitas Georgas, Marie-Aude Pradal

Abstract: Research is being conducted with the primary objective of evaluating what components of a highly detailed coastal ocean model, the sECOM hydrodynamic model [e.g., Blumberg and Georgas, 2008], are important for predicting storm surge flooding, and what aspects have negligible influence. The research utilizes a highly detailed hydrodynamic modeling system that has been demonstrated to provide highly accurate storm surge predictions in an operational context. The experiments will add and remove several components of the model's inputs and capabilities, including (1) two-dimensional (parameterized) versus three-dimensional (fully dynamic) modeling, (2) including rain and freshwater inputs, (3) nesting the model inside a larger-scale ocean model, and (4) including tides. Three storms from March through April 2010 are being modeled: one storm with wind and rain, another with only rain, and one intermediate case. The first storm caused the largest surges in the New York City area since 1992, at 1.2 m, and the other two caused minor surges there; all three storms caused high water levels at Albany, up the Hudson River.



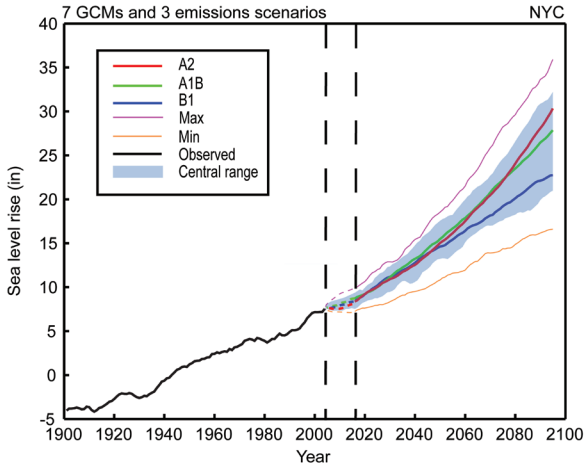
The New York Harbor Observing and Prediction System (NYHOPS) incorporates sECOM to provide accurate simulations of rainfall- and wind-driven flooding.

Initial Results: The research is in its relatively early stages, but one important finding is that the New York Harbor Observing and Prediction System (NYHOPS), the operational system that utilizes the sECOM model with all available detailed inputs, accurately simulates the merging of rainfall- and wind-driven flooding on the Hudson River. This is important because hydrology and oceanography have generally not been dynamically merged in prior efforts at flood modeling.

Project: Coastal flood risk analysis for the urban Northeastern Corridor, today and with future sea levels

Investigators: Alan Blumberg, Julie Pullen, Radley Horton, Vivien Gornitz, Philip Orton, Nickitas Georgas, Marie-Aude Pradal, Timothy Hall

Abstract: The Northeastern U.S. urban corridor of New York City, Philadelphia and Boston is threatened today by coastal storms, and climate change is likely to increase this threat due to



Sea level rise projections developed by members of the CCRUN climate group will be used with the coastal group's storm surge models to evaluate future coastal flood risk in the CCRUN project area.

predicted changes such as sea level rise. A project is outlined here that would merge the most successful existing tools for predicting coastal storm winds and storm surges and their evolution in a changing climate. A combination of stochastic and deterministic models, ranging from highly simplified to highly detailed, will be utilized. Results from several global climate models will be utilized to produce multi-model best estimates (including uncertainty ranges) of the impact of climate change on sea level, storm frequency and storm intensity. The primary objective of the project is to produce probabilistic risk assessment for each city in the present, the 2050s and the 2080s, using stakeholder-defined metrics for urban watersheds. Major innovations beyond other prior studies include a) the use of a highly detailed, extensively validated ocean model, alongside a simplified model, to provide probabilistic, yet accurate forecasts; and b) use of a framework that includes both tropical and extra-tropical storms.

Stakeholders: New York City Department of Environmental Protection/Environmental Planning and Analysis

Sector: Health

Project: Heat-related mortality risks in the urban northeast under a changing climate

Investigators: Patrick Kinney, Mark Arend, Elisaveta Petkova, Julia Morrison, Mayu Sasaki, Radley Horton

Abstract: This project seeks to analyze current and projected future temperature-related mortality impacts across a range of climate change models and scenarios. A statistical model using Poisson regression is being developed to quantify the exposure-response relationships, linking daily temperature and death counts at the urban scale in New York, Boston, and Philadelphia; this model will be created through an analysis of historical mortality data, controlling for air quality, time-trends, seasons, and day-of-week effects. We will then apply this relationship to future projections of daily temperatures for the 2020s, 2050s and 2080s over New York, Boston, and Philadelphia to assess potential future risks under different scenarios of climate change. Percentage changes in mortality in both winter and summer are calculated relative to the minimum mortality temperature (MMT), defined as the minimum point on the curve relating mortality to daily mean temperatures. The heat- and cold-related deaths in 30 year periods centered on the 1980s, 2020s, 2050s and 2080s will estimated by integrating the results from the climate models and the empirical exposure-

response relationship. We will also develop vulnerability indicators for the cities of interest, and test whether mortality impacts vary in association with these indicators.

Initial results: Preliminary results for Manhattan suggest that, over a range of models and scenarios of future greenhouse gas emissions, increases in heat-related mortality will likely outweigh reductions in cold-related mortality. Further, while the two emissions scenarios used produce similar mortality estimates through the mid-21st century, the lower-emission B1 scenario results in substantially smaller annual mortality impacts by the 2080s.

Stakeholders: New York City Department of Health and Mental Hygiene; Boston Public Health Commission

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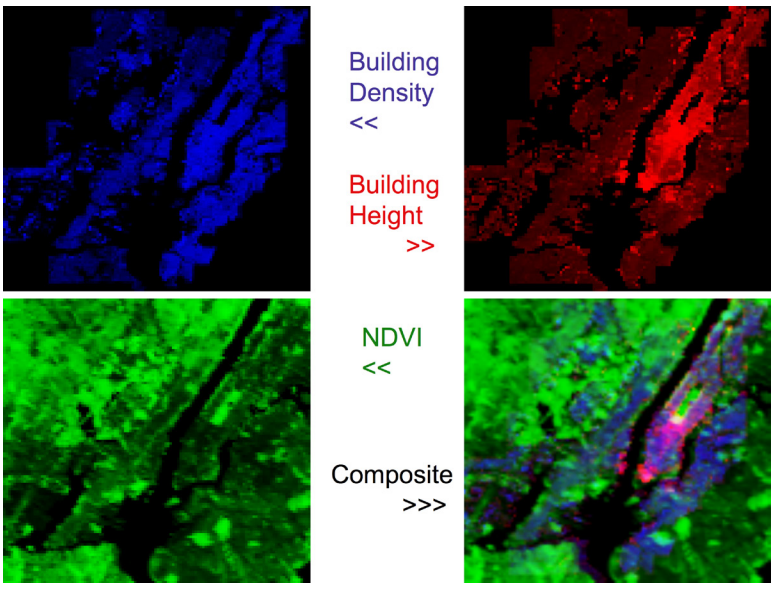
Project: Characterizing urban thermal neighborhoods for climate health impacts

Investigators: Reza Khanbilvardi, Brian Vant-Hull, Mark Arend

Abstract: A city's urban heat island can be subdivided into physically defined neighborhoods that respond differently to large scale environmental forcing. The observed bias from the modeled temperature would be similar throughout a thermal neighborhood, but vary between neighborhoods. The initial hypothesis is that average building height, building density, and vegetation density can be used to define thermal neighborhoods by applying cluster analysis to these physical variables plus the spatial location. To test if the neighborhood assignments are meaningful, a field campaign will measure temperatures throughout the urban heat island and see if these field measurements do indeed cluster inside each neighborhood.

After the thermal neighborhoods are established, records and ongoing data collection from an array of weather stations throughout the city may be used to monitor the temperature. Station data will be compared to the city wide urban neighborhood field campaign to assess biases. It is expected that other variables such as cloudiness, wind, and soil moisture will affect these biases. A response matrix containing all combinations of the predictive variables (predicted temperature, cloud cover, wind, moisture) will catalogue the temperature biases for each neighborhood depending on environmental conditions.

Stakeholders: New York City Department of Health and Mental Hygiene



Surface variables used to characterize urban heat island effects and define thermal neighborhoods include building height, building density, and vegetation density (NDVI).

Project: Reducing mortality from heat waves in the urban Northeast

Investigators: Patrick Kinney, Mark Arend, Malgosia Madajewicz, Elisaveta Petkova, Julia Morrison, Mayu Sasaki

Abstract: Heat waves are a leading cause of weather-related mortality in the northeastern U.S., particularly among vulnerable populations. Thus, a good understanding of effective interventions to reduce heat wave-related mortality is essential for public health adaptation to climate change in the region. However, the relationship between utilization of heat health warning systems and mortality during heat wave episodes has yet to be well understood and quantified. A major barrier to assessing the effectiveness of heat health warning systems is the lack of clearly outlined decision making process, and interactions among the various organizations and communities before and during heat wave events. An important consequence of this ambiguity is the suboptimal utilization of climate information in public health planning, decision making and communication. The project will address these challenges by documenting current use of climate information by stakeholder institutions in Boston, Philadelphia and New York and building detailed institutional maps of their decision making processes. The health team will also analyze the relationship between heat waves and mortality in the three cities and provide an assessment of the effectiveness of existing heat health warning systems. Based on this work, the team will also develop climate information and decision support tools in collaboration with stakeholders and outline strategies for improved public health response to heat waves at the city level.

Stakeholders: New York City Department of Health and Mental Hygiene; Boston Public Health Commission

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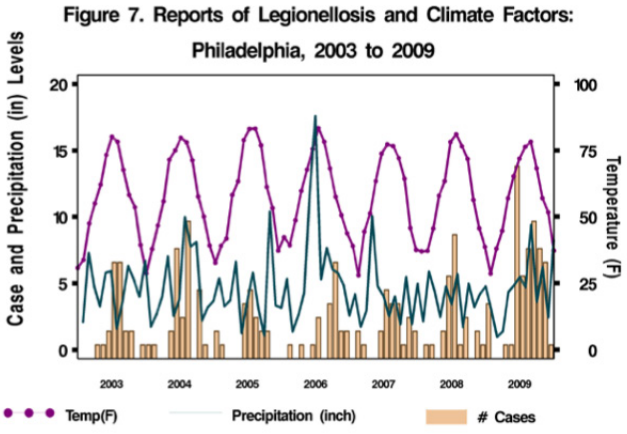
Project: Water and the public health connection in Philadelphia

Investigators: Elizabeth DeVilbiss, Franco Montalto, Amy Auchincloss, Charles Haas

Abstract: The relationship between urban infrastructure, climate, and public health is being studied through a review of medical case histories (principally microbial illnesses and asthma) that have been strongly correlated with climatic conditions. Specifically, we are investigating the relationships between varying levels of climatically impacted infrastructure performance and key indicators of public health. Such relationships will then be associated with forecasted climate change, and future potential for outbreak of disease assessed.

Stakeholders: Philadelphia Department of Public Health/Air Management Services Division; Philadelphia Department of Public Health/Environmental Health Services Division



The Legionella *bacterium causes a greater incidence of disease in the summer months, especially after days with increased humidity. It is also a common contaminant in public water supplies. (Philadelphia Department of Public Health, 2009 Annual Report)*

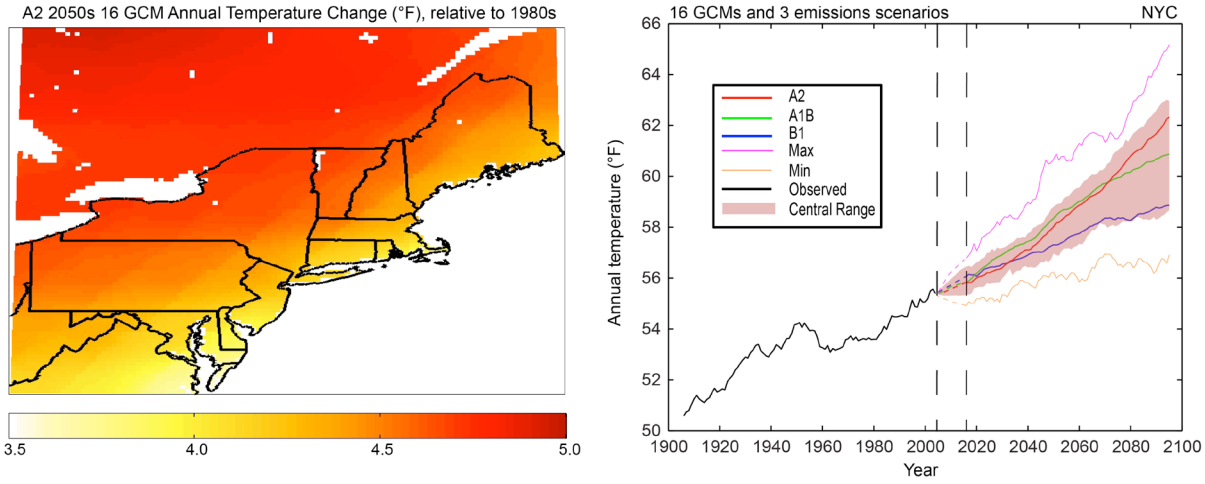
Cross-Cutting Theme: Climate

Project: Climate change scenarios and downscaled climate projections for New York, Boston and Philadelphia

Investigators: Radley Horton, Cynthia Rosenzweig, Daniel Bader

Abstract: The large number of available Global Climate Models (GCMs) makes possible the model-based probabilistic assessment of future climate projections across a range of climate sensitivities. Although GCMs are the primary tool used for long-range climate prediction, the spatial scale of climate model output is still too coarse for most impacts studies and decision-support purposes at the urban scale. Statistical downscaling, which involve statistically relating large-scale climate features to fine-scale climate data for a region of interest, can address this spatial resolution gap. This project will create downscaled climate projections for the CCRUN project are by applying two such techniques. The first downscaling technique, called the BCSD approach, was developed for hydrologic impact studies (Wood et al. 2004) and is well tested, automated, and computationally efficient enough to be easily applied to ensembles of model projections. The application of this technique produces spatially continuous, fine-scaled gridded output of precipitation and temperature for regional and local impacts analysis. The next downscaling technique uses the monthly change fields generated for temperature by the BCSD approach, and applies the results to validated historical temperature data from multiple stations within urban areas to create daily projections for stations both within urban areas and in the surrounding regions.

Stakeholders: New York City Department of Environmental Protection; New York City Department of Health and Mental Hygiene; Boston Public Health Commission



At left, a map of the temperature change (°F) across the Northeast for the 2050s relative to the 1980s base period, for the A2 scenario averaged across the 16 GCMs to form an ensemble mean. At right, combined observed (black line) and projected temperature changes for New York City. Projected model changes through time are applied to the observed historical data. The three thick lines (green, red, blue) show the average for each emissions scenario across the 16 GCMs. Shading shows the central range. The bottom and top lines, respectively, show each year's minimum and maximum projections across the suite of simulations. A ten-year filter has been applied to the observed data and model output. The dotted area between 2005 and 2015 represents the period that is not covered due to the smoothing procedure.

Project: Space-time properties of extra-tropical storms along the US northeastern seaboard – present and future

Investigators: Yochanan Kushnir, Radley Horton, Lisa Goddard, Upmanu Lall, Alan Blumberg, Julie Pullen, Philip Orton, Suzana Camarga, Andrew Robertson

Abstract: Extratropical storms are associated with well defined circulation patterns that affect the location of coastal impacts and their intensity. Using newly available reanalyses of weather data of the past century and more, we will generate robust estimates of probabilities by frequency, spatial extent, track, and intensity of storms that affect the Northeast coast and close by inland regions and determine trends and variability patterns. In particular we will explore the possibility of creating information that is conditional on large-scale circulation states such as those related to the El Niño/Southern Oscillation and the North Atlantic Oscillation phenomena. This work will enable improved estimates of the space-time, conditional probabilities of wind and precipitation extremes, allow improved downscaling of future model scenarios, and provide probabilistic scenarios for forcing hydrodynamics coastal models to assess coastal inundation and impact on infrastructure.

Project: Climate indicators and monitoring

Investigators: Radley Horton, Cynthia Rosenzweig, Dan Bader

Abstract: Climate indicators include extremes of temperatures, precipitation, sea level and storm surge, as well as winds and other severe weather metrics such as lightning, hail, freezing precipitation, and coastal storms. We have received feedback from our stakeholders (for example in Boston) on the different ways that different stakeholders would like this information presented (e.g., mean value vs. central range). We have also developed a template and core content for an indicator and monitoring network focused on the impacts of climate change. Examples of indicators currently tracked by New York City stakeholders can be found in the Mayor's Management Report (MMR), Citywide Agency Performance Reports (CPRs), and PlaNYC/sustainability reports. Raw data is available at NYCStat, managed by the Mayor's Office of Operations: http://www.nyc.gov/html/ops/nycstat/html/home/home.shtml.

New York City's PlaNYC web site allows public tracking of certain key climate indicators.

Stakeholders: New York City Department of Long-Term Planning and Sustainability; New York City Department of Health and Mental Hygiene; Boston Public Health Commission

Cross-Cutting Theme: Vulnerability/Evaluation

Project: Evaluation of CCRUN

Investigator: Malgosia Madajewicz

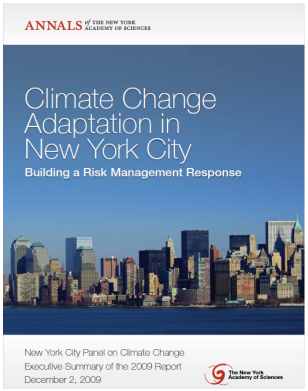
Abstract: The Consortium for Climate Risk in the Urban Northeast (CCRUN) is working with stakeholders in the urban corridor stretching from Boston to Philadelphia to improve the management of climate risks and adaptation to climate change. CCRUN researchers and the decision makers at stakeholder institutions are working together to develop ways in which climate science, and information tools based on climate science (e.g., seasonal forecasts), can help design policies and make decisions to reduce vulnerability to climate events in three areas: 1) water (including problems of flooding, water availability and quality); 2) health (including the effect of heat waves and air quality); and 3) coastal zones that are vulnerable to storm surges. The research is also helping to understand which population groups are most vulnerable to different risks and why, and what changes in policies and in the way that institutions serve these populations can help to reduce vulnerability.

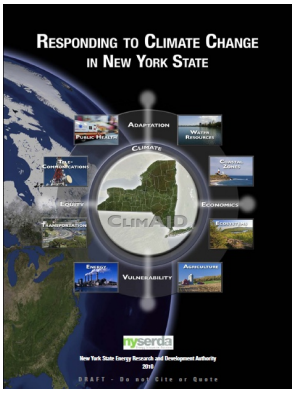
An important and novel component of CCRUN is an impact evaluation, the objective of which is to document and communicate what the effective approaches are to reducing vulnerability to climate risks in the water, health, and coastal zone sectors under different climatic, environmental, and socio-economic conditions. An important component of the research is estimating the economic value of climate information based on realized reductions in vulnerability. We want to understand which approaches undertaken by CCRUN work and which do not; for whom they work, and under what conditions; why the approaches work; and how large the benefits are of each. The research will produce evidence that can guide the design of strategies to improve adaptation in other urban settings.

Project: History of climate adaptation efforts in New York City and New York State

Investigator: Shiv Someshwar

Abstract: Institutional acceptance of the need for climate change adaptation planning, and the actual incorporation of such into operations, often "starts small" with pioneering efforts at the agency level but then expands over time. This project will map the development of climate change adaptation efforts in New York City and New York State, reviewing the chain of key decision-making processes and institutions that have led to the current state of planning and guiding future planning of both. The identification of the the most successful pathways to the incorporation of climate change adaptation into the City and State's long-term planning, as well as the barriers to adoption, can be useful in streamlining the planning process for other state and local governments.





Workshops

CCRUN investigators have sponsored or participated in the following workshops and seminars (in chronological order):

University of Massachusetts-Amherst Environmental and Water Resources Engineering Seminar Series, Fall 2010/Spring 2011 – Richard Palmer and Casey Brown (Hosts)

New England Regional Climate Modeling Workshop, University of Massachusetts-Amherst, 8 October 2010 – Ray Bradley and Richard Palmer (Hosts), Radley Horton (Presenter)

Mid-Atlantic Bight Physical Oceanography and Meteorology (MABPOM) Meeting, Stevens Institute of Technology, Hoboken, NJ, 27-28 October 2010 – Alan Blumberg (Host)

Mid-Atlantic Coastal Ocean Observing Regional Association (MACOORA) Annual Meeting, Stevens Institute of Technology on 27-28 October 2010 – Alan Blumberg (Host), Radley Horton (Presenter)

Federal Climate Change and Water Working Group (CCAWWG) Meeting, Lakewood, CO, 9-10 November 2010 – Radley Horton (Participant)

National Climate Assessment (NCA) Regional Sectoral Workshop, Washington D.C., 15-18 November 2010 – Cynthia Rosenzweig (Panelist)

Water Utility Climate Alliance - Piloting Utility Modeling Applications (WUCA-PUMA) Workshop, San Francisco, CA, 1-3 December 2010 – Radley Horton (Participant)

National Climate Assessment (NCA) Scenarios Workshop, Washington D.C., 6-10 December 2010 – Cynthia Rosenzweig (Panelist)

National Parks Service Climate Scenario Planning Workshop, Shepherdstown, WV, 7-8 December 2010 – Radley Horton (Discussion Leader)

NASA Ames Climate Change Adaptation Symposium, Moffett Field, CA, 4 February 2011 – Cynthia Rosenzweig and Radley Horton (Presenters)

Climate Change Education Partnership Workshop, New York, NY, 7-8 March 2011 – Radley Horton (Host), Linda Sohl and Dan Bader (Presenters)

Massachusetts State Climate Protection Network Meeting, Marshfield, MA, 10 March 2011 – Cynthia Rosenzweig (Presenter)

Connecticut River Environmental Flow Workshop, Northampton, MA, 10-11 March 2011 – Richard Palmer and Casey Brown (Hosts)

1st Annual Hydroclimate Outlook Forum, University of Massachusetts-Amherst, 15 March 2011 – Casey Brown (Host)

Regional Downscaling Using RCMs for Stakeholder Applications, Trieste, Italy, 21 March 2011 – Radley Horton (Participant)

Regional Urban Areas Security Initiatives & Planning Workshop, All Hazards Consortium, Newark, NJ, 21-22 March 2011 – Julie Pullen (Participant)

National Climate Assessment (NCA) Societal Indicators Workshop, Washington D.C., 28-29 April 2011 – Robert Chen (Steering Committee co-chair and lead author of white paper), Radley Horton (Panelist)

Presentations

Adamec, K., 2011, Sub-daily optimization modeling for hydropower and the environment: UMass-Amherst Environmental and Water Resources Engineering Seminar, 15 Apr.

Blumberg, A., 2011, Observing and forecasting storm impacts in New York/New Jersey waters (invited), UMass-Amherst Climate Change, Policy and Energy Solutions Seminar, 9 March.

Brown, C., 2011, Decision-scaling and robust adaptation in water resources planning: AWRA's 2011 Spring Specialty Conference "Managing climate change impacts on water resources: adaptation issues, options, and strategies," Baltimore, Maryland, 18 Apr.

Brown, C., 2010, Actionable climate information for water resources planning under climate uncertainty: Climate Change and Water Working Group workshop - Assessing a portfolio of approaches for producing climate change information to support adaptation decisions, UCAR, Boulder, Colo., 9 Nov.

Brown, C. and Ahlfeld, D., 2010, "Actionable" climate information for water resources planning under climate uncertainty: New England Regional Climate Modeling Workshop, UMass-Amherst, 8 Oct.

DiGiovanni, K.A., Montalto, F.A., Gaffin, S., and Rosenzweig, C., 2010, Evaluation of physically and empirically based models for the estimation of green roof evapotranspiration: Abstract H53J-01 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Horton, R.M., Rosenzweig, C., Lall, U., and Kinney, P.L., 2011, The Consortium for Climate Risk in the Urban Northeast: 91st American Meteorological Society Annual Meeting, Seattle, Wash., 23-27 Jan.

Horton, R., Ruane, A., and Winter, J., 2010, Applying regional climate models at NASA GISS/ Columbia University CCSR: Currents activities, initial results, and future needs: New England Regional Climate Modeling Workshop, UMass-Amherst, 8 Oct.

Mohammed, I.N., Tarboton, D.G., Cohen, R., and Lall, U., 2010, An examination of the sensitivity of runoff in the Northeastern US to 20th century development: Abstract H43C-1263 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Montalto, F.A., Waldman, A., and Travaline, K., 2010, The emergence of urban hydrologic outcomes from inter-related social and physical dynamics: Abstract H32A-07 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Montalto, F., 2010, Exploration of how climatological factors could influence the buildout of green infrastructure in urban watersheds: New England Regional Climate Modeling Workshop, UMass-Amherst, 8 Oct.

Pitta, B., 2010, A decision support system for reservoir operations to improve ecological targets in the Connecticut River watershed: UMass-Amherst Environmental and Water Resources Engineering Seminar, 5 Nov.

Rosenzweig, C., 2010, Linking federal, state and local adaptation strategies in New York (invited): Abstract NH43B-07 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Sohl, L., 2011, Climate Change in the NY Metro Area and Long Island: Understanding Impacts and Managing Risks: South Shore Estuary Reserve Council Monthly Meeting, 24 Mar.

Yu, Z., DiGiovanni, K.A., and Montalto, F.A., 2010, How well can calibrated Thornthwaite Mather models predict the variability in soil moisture observed in green infrastructure facilities?: Abstract H11H-0923 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.

Outreach and Communications

Web sites:

CCRUN (http://www.ccrun.org): This is the official web site for the CCRUN RISA. The site will serve as the main public information portal on CCRUN team members and their projects and activities, as well as a repository for stakeholder-relevant information.

SeaAndSkyNY Blog (http://seaandskyny.com): This multi-author science blog was launched November 18th, 2010, with the goal of building public knowledge of coastal flooding and sea level rise threats, and informing both stakeholders and journalists on research in progress by CCRUN's coastal group. Three blog posts have been written summarizing the history of storm surges and current research goals for the New York City region, and are accessible at http://seaandskyny.com/tag/storm-surge/ :

- Rain- and Wind-Driven Coastal Flooding, by Philip Orton, April 16, 2011
- Can NYC Beaches Get Swallowed by the Sea in a Storm? by Philip Orton, March 10, 2011
- The NYC Storm Surge Threat, by Philip Orton, February 14, 2011

The Connecticut River Project Wiki (http://ctriver.ecs.umass.edu/wiki/index.php/Main_Page): This wiki records the progress being made by The Nature Conservancy, the US Army Corps of Engineers New England District Office, the University of Massachusetts Amherst, the USACE Hydrologic Engineering Center (HEC), and the US Geologic Survey (USGS) on the Connecticut River Project.

Climate Change Impacts on the New England Environment (http://www.cns.umass.edu/neclimate or http://www.neclimate.info): This web site provide news and information about research, events, and workshops at UMass-Amherst, the Five Colleges, and around New England related to climate change impacts in our region. Our goals include continuous learning about on-going interdisciplinary research on climate change and impacts, encouraging collaboration within the New England climate research community, making connections between regional stakeholders and climate researchers, as well as helping to focus future directions of regional climate change research. The site includes upcoming events and recordings of past presentations, bibliography of articles that relate to climate change impacts on the New England environment, and links to climate change resources on academic and government levels.

In the news:

"UMass professor receives grant to study Connecticut River," *The Massachusetts Daily Collegian*, published online 9 March 2011. Available at (http://dailycollegian.com/2011/03/09/umass-professor-receives-grant-to-study-connecticut-river-2/)

Publications and Reports

*** Although most of the following publications were written prior to the launch of CCRUN, they relate directly to the projects undertaken in Year 1 and so are included here for reference.*

Alemu, E.T., Palmer, R.N., Polebitski, A.S., and Meaker, B., 2011, Decision support system for optimizing reservoir operations using ensemble streamflow predictions, *ASCE Journal of Water Resources Planning and Management*, v. 137, p. 72-83, doi:10.1061/(ASCE)WR.1943-5452.0000088.

Basinger, M., Montalto, F., and Lall, U., 2010, A rainwater harvesting system reliability model based on nonparametric stochastic rainfall generator: *Journal of Hydrology*, v. 392, p. 105-118, doi: 10.1016/j.hydrol.2010.07.039.

Civerolo, K., Hogrefe, C., Zalewsky, E., Hao, W., Sistla, G., Lynn, B., Rosenzweig, C., and Kinney, P.L., 2010, Evaluation of an 18-year CMAQ simulation: Seasonal variations and long-term temporal changes in sulfate and nitrate: *Atmospheric Environment*, v. 44, p. 3745-3752, doi: 10.1016/j.atmosenv.2010.06.056.

Hogrefe, C., Hao, W., Zalwsky, E.E., Ku, J.-Y., Lynn, B., Rosenzweig, C., Schultz, M.G., Rast, S., Newchurch, M.J., Wang, L., Kinney, P.L., Sistla, G., 2011, An analysis of long-term regional-scale ozone simulations over the Northeastern United States: variability and trends: *Atmospheric Chemistry and Physics*, v. 11, p. 567-582, doi:10.5194/acp-11-567-2011. Available at http://www.atmos-chem-phys.net/11/567/2011/acp-11-567-2011.html.

Horton, R. Rosenzweig, C., Ramaswamy, V., Kinney, P., Mathur, R., Pleim, J., and Rao, V.B., 2010, Integrated climate change information for resilient adaptation planning: *EM Magazine*, v. 14, p. 14-25.

Horton, R.M., V. Gornitz, D. Bader, A. Ruane, and C. Rosenzweig, 2011 accepted, A Climate Change Assessment Method for Urban Adaptation: Case Study for New York City, *Journal of Applied Meteorology and Climatology*.

Jung, K.-H., Patel, M.M., Moors, K., Kinney, P.L., Chillrud, S.N., Whyatt, R., Hoepner, L., Garfinkel, R., Yan, B.Z., Ross, J., Camann, D., Perera, F.P., and Miller, R.L., 2010, Effects of heating season on residential indoor and outdoor polycyclic aromatic hydrocarbons, black carbon, and particulate matter in an urban birth cohort: *Atmospheric Environment*, v. 44, p. 4545-4552, doi: 10.1016/j.atmosenv.2010.08.024.

Jung, K.-H., Moors, K., Yan, B., Chillrud, S.N., Kinney, P.L., Whyatt, R., Camann, D., Perera, F.P., Miller, R.L., 2011, Vertical gradients of residential indoor and outdoor polycyclic aromatic hydrocarbons, black carbon, particulate matter in New York City: *Epidemiology*, v. 22 (January Supplement), p. S211, doi: 10.1097/01.ede.0000392331.72140.a3

Li, T.T., Horton, R., and Kinney, P., 2011, Projecting temperature-related mortality impacts in New York City under a changing climate: *Epidemiology*, v. 22 (January Supplement), p. S15, doi: 10.1097/01.ede.0000391700.42565.0a.

Polebitski, A.S., Palmer, R.N., and Waddell, P., 2011 in press, Evaluating water demands under climate change and transitions in the urban environment, *ASCE Journal of Water Resources Planning and Management,* doi:10.1061/(ASCE)WR.1943-5452.0000112.

Rosenzweig, C., Solecki, W.D., Blake, R., Bowman, M., Faris, C., Gornitz, V., Horton, R., Jacob, K., LeBlanc, A., Leichenko, R., Linkin, M., Major, D., O'Grady, M., Patrick, L., Sussman, E., Yohe, G., and Zimmerman, R., 2011 in press, Developing coastal adaptation to climate change in the New York City infrastructure-shed: process, approach, tools, and strategies: *Climatic Change*, v. 106, p. 93-127, doi: 10.1007/s10584-010-0002-8 (published online 26 Feb 2011).

Rosenzweig, C., Solecki, W., Hammer, S.A., and Mehrotra, S., 2010, Cities lead the way in climate-change action: *Nature*, v. 467, p. 909-911, doi: 10.1038/467909a.

Sheffield, P.E., Weinberger, K.R., and Kinney, P.L., 2011, Climate change, aeroallergens, and pediatric allergic disease: *Mt. Sinai Journal of Medicine*, v. 78, p. 78-84, doi: 10.1002/msj.20232.

Someshwar, S., 2011, Expert Perspective: Adaptation to climate change: Moving beyond "reactive" approaches: *WRI World Resources Report*, available at http://www.worldresourcesreport.org./responses/adaptation-climate-change-moving-beyond-reactive-approaches.

Spatari, S. Yu, Z., and Montalto, F.A., 2011 in press, Life cycle implications of urban green infrastructure: *Environmental Pollution*, doi: 10.1016/j.envpol.2011.01.015, available online 16 February 2011.

Zhou, J.P., Erdal, Z.K., McCreanor, P.T., Montalto, F., 2010, Sustainability: *Water Environment Research*, v. 82, p. 1376-1395, doi: 10.2175/106143010X12756668801293.

Links to Other NOAA Programs

National Weather Service Northeast River Forecast Center
NOAA Regional Climate Services, Eastern Region