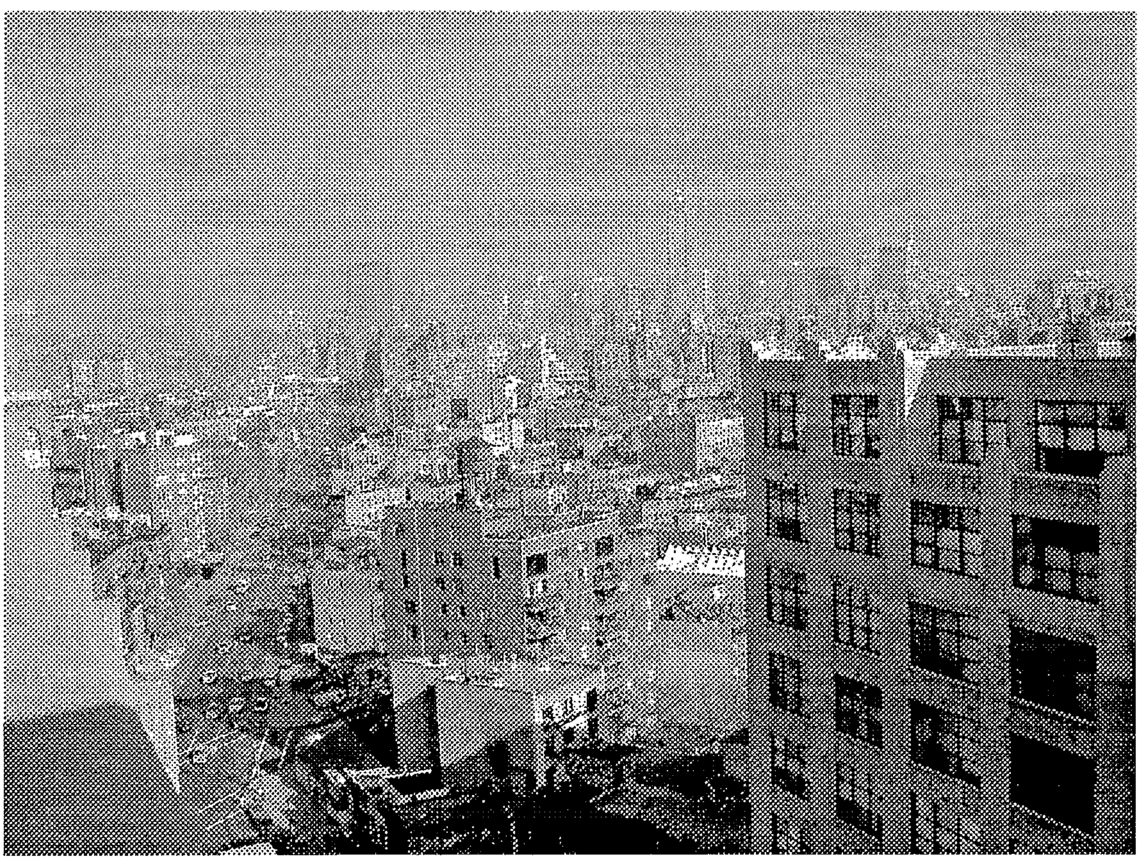
BNL-71195-2003

BROOKHAVEN NATIONAL LABORATORY

EML Environmental Measurements Laboratory

Urban Atmospheric Observatory (UAO)
First Planning Workshop
27-28 January 2003

WORKSHOP SUMMARY



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27 March 2003

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Work supported in part by the U.S. Department of Energy under contract No. DE-AC02-98CH10886.

CONTENTS

Abstract

The Urban Atmospheric Observatory (UAO) First Planning Workshop was held on 27-28 January 2003 at the Environmental Measurements Laboratory (EML) in downtown Manhattan, New York City. The meeting was well attended by local, state, and national administrators, as well as scientists and engineers from the national laboratories and academia. The real-time intensive UAO is a necessary step toward the development and validation of new technologies in support of the New York City emergency management and anti-terrorism effort. The real-time intensive UAO will be a dense array of meteorological instrumentation, remote sensing and satellite products and model output, as well as radiation detection, gamma spectrometer and aerosol measurements focused onto a small area in the heart of Manhattan. Such a test-bed, developed in a somewhat homogeneous urban area, and with a well-developed communication and data collection backbone, will be of immense utility for understanding how models of all scales can be improved and how they can best be integrated into the city's emergency program. The goal of the First Planning Workshop was to bring together a small group of experts in the fields of urban meteorology, modeling from mesoscale to fine-mesh computational fluid dynamics, instrumentation, communications and visualization, in order to (1) establish the importance of the observational program, (2) define the most efficient and cost-effective design for the program, (3) define needed intensive observational efforts and establish a schedule, and (4) define the importance of the UAO in emergency operations. The workshop achieved its goals with the enthusiastic participation of over forty persons. There was a synthesis of ideas towards a world-class facility that would benefit both immediate emergency management activities and, over an extended time, the entire field of urban meteorology and contaminant dispersion modelling.

Executive Summary

The UAO will develop along two complementary lines. First and foremost, it will be an observational tool that will support emergency operations by providing a dense coverage of meteorological information, especially winds, turbulence data, and radiological information. The real-time observations will provide a backbone to emergency model products. Second, it has the possibility of becoming a scientific facility of world-class proportions. The two visions, real-time emergency support and scientific research, are inter-connected. Real-time data products can be provided in short order, then over time can be expanded and improved as the science develops.

The real-time intensive UAO is a necessary step toward development and validation of new technologies in support of the New York City emergency management and anti-terrorism effort. A general description of the real-time intensive UAO is a dense array of meteorological instrumentation, remote sensing, satellite products and model output, as well as radiation detection, gamma spectrometer and aerosol measurements focused onto a small area in the heart of Manhattan. The goal of the First Workshop was to establish the importance of such an undertaking and to formulate an implementation strategy.

Urban meteorology is still in its infancy, especially for densely built-up downtown areas, and the New York City area provides abundant opportunities to expand that knowledge. Improved numerical models must include building geometries, deep canyons, solar heating, infrared cooling, and vegetation. Mesoscale processes such as sea breezes produce sudden shifts in the flow over the city. Cities, and especially a city like New York, must be accounted for at all scales, from large-scale climate models to regional mesoscale models down to fine-mesh fluid dynamic models.

New York City is a world business center and a target of terrorist attack. The detection of radiation can allow immediate intervention in case a "dirty bomb" (made from radioactive material) is used by terrorists. An intensive network of radiation sensors can quickly detect the movement of a radioactive cloud, information that is crucial to the Office of Emergency Management during emergency operation. The data obtained from radiation sensors can also be used for validating the urban model prediction of transport of radioactive clouds.

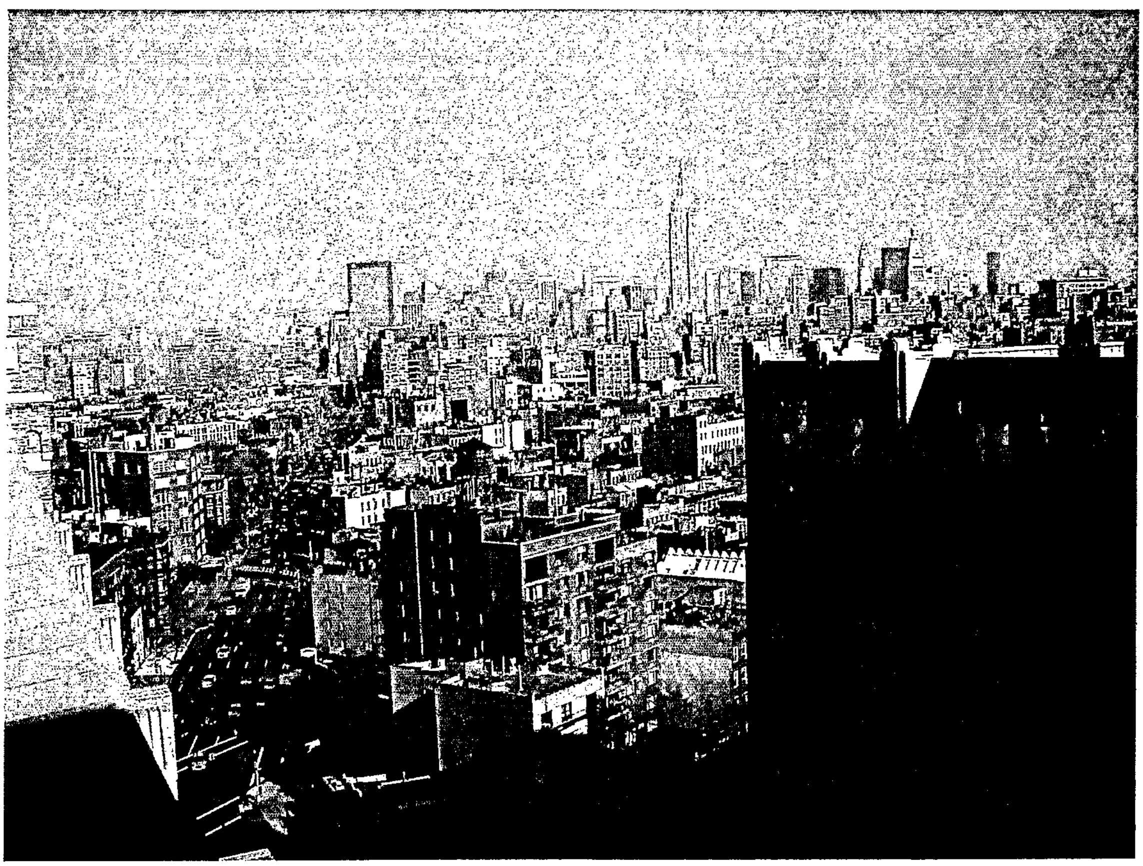
Cities have a complicated thermodynamic response, which is most pronounced during times of strong solar heating. Their vast expanse of concrete and buildings, especially in the density found in Manhattan, are very efficient at trapping heat during the daytime. The later release of this creates an "urban heat island" that has considerable influence on large-scale air flow and dispersion over the city. The nocturnal heat island means that while the surrounding marine and rural boundary layers are cool and stable, the city can remain well mixed. New York City, like most coastal cities, has a pronounced sea-land breeze system that creates daily, sudden shifts in wind speed and direction. Currently, the interplay between the large-scale weather and the city is incorporated in models in a rudimentary way. Any new urban modelling system must include these effects before it can provide reliable emergency support.

A gas release will be distributed through the city in complicated ways while it is dispersed by the local turbulence. Models that predict the fate of plumes exhibit considerable sensitivity to such initialization parameters as wind direction or atmospheric stability. The flow through the deep canyons and the wakes behind tall buildings can be simulated by the fine mesh (1 m resolution) Computational Fluid Dynamics (CFD) models, but these require considerable resources and computation time. At this time, CFD models are not useful as real-time predictors for emergency response, even though they can be extremely useful for understanding observational data and improving/validating models. Although a new breed of hybrid, urban-scale dispersion model, the Urban Dispersion Model (UDM), based on building-by-building dynamic, has promise to provide the speed and accuracy sufficient for emergency response, it will need to be validated with observations.

When a contaminant is released below ground in the subway system, the situation becomes much more complex. The subways force air through the tunnels, where the ventilation system and the air propelled by the trains can transport contaminant far from the original source point. The thousands of vents in the subways with direct connection to the street above can create a network of area and line sources of contaminant.

The UAO will be a testbed where emerging technologies--models, communication systems, sensor networks, training exercises--can be evaluated and improved. It will be a prototype for similar observation networks in other metropolitan areas. A new class of instrumentation–radars, lasers, chem-bio sensors–is needed to support more traditional urban meteorological observations and for emergency management, and the UAO will be a primary arena for evaluation of these new technologies. The UAO customer base includes the NYC Office of Emergency Management, the Departments of Defense and Homeland Security, National Oceanic & Atmospheric Administration (NOAA), Environmental Protection Agency (EPA), media, police, and studies on the effects of climate change on the urban environment.

The general consensus of this workshop is that the UAO will improve the tools used by emergency managers to direct response activities, will become a world class research facility, that attracts an international cadre of scientists, and will lead to an accelerated understanding of the many uncertainties inherent in currently used models. The UAO will become the "place to go" to do research on urban meteorology and dispersion -- all to the benefit of New York City and its inhabitants.



View towards the north from the roof of the EML building. The cityscape grows from the water's edge to the midtown area (anticipated UAO intensive area).

RECOMMENDATIONS

- The planning and design for the UAO should begin now. Existing data sources in NYC should be surveyed and communications initiated with the Office of Emergency Management, NARAC, and other emergency responding agencies. The current "Pilot Exercise" on the EML building is a good beginning.

- The UAO should be a consortium from National Laboratories, academia, state and local emergency management, and the military. Funding will require support from a broad base of agencies as significant expertise in this field resides outside the United States, and other countries should be encouraged to participate.

- The best location for the intensive network would cover midtown, bounded approximately by 30th and 45th streets and 3rd to 9th Avenues. A lesser density of observations would cover the remainder of the city. This area was chosen as a compromise between expected resources (costs and manpower required) and scientific suitability.

- The vertical distribution of winds, and atmospheric structure within and above the city on time scales from annual, seasonal, to diurnal, are very important. The vertical structure from the urban canopy layer up to heights of 1000-2000 m should be understood, and must be reliably predicted by regional models.

- The midtown site would have a reasonable distribution of permanent stations, with one or two areas of high-density observations aimed at certain features that our current understanding is lacking. Examples include deep urban canyons, divergent canyons, isolated building wakes, and the influence of a few very tall buildings on the general urban boundary layer flow. Radiation detection data should be used for validating the urban model prediction of transport of radioactive clouds and aerosols.

- A series of intensive studies, typically of 1-2 months in duration, should be carried out and scientists from the international community are invited to participate. Intensive studies will focus on the research mentioned above.

- Interaction of the subway system with the atmosphere above the street surfaces, and associated flow and dispersion processes in and above the subways, should be improved and validated.

- Begin now. Even one or two real-time data sources would provide considerable support to the emergency modelling effort.

ABSTRACTS OF PRESENTATIONS

Opening and Welcome

Mitchell D. Erickson, Director of EML

On March 1, 2003, the Environmental Measurements Laboratory (EML) will transition into the new Department of Homeland Security (DHS) under the Science and Technology Directorate. The other Directorates are Information Analysis & Infrastructure Protection, Border & Transportation Security, and Emergency Preparedness & Emergency Response. EML's primary missions will be to prevent, protect against and respond to radiological/nuclear threats and to develop standards for homeland security technologies. EML has initiated several DHS projects. Among them are: (1) developing standards for pagers, portable detectors and portal monitors in collaboration with NIST and ANSI; (2) developing and installing a prototype radiation monitoring network to test systems integration and sensor performance; (3) coordinating Radiation Detection Equipment Field Trials at PANYNJ with BNL; and (4) establishing an urban-scale atmospheric dispersion model pilot observatory with BNL.

"Welcome to EML; have a productive meeting; and let's make the Urban Atmospheric Observatory Planning Workshop a success for America's counter-terrorism efforts."

Welcome

Ralph James, Associate Laboratory Directory for EENS, BNL

Brookhaven National Laboratory recognizes the importance of the Urban Atmospheric Observatory (UAO) and its goal to support emergency management while providing a platform for the improvement of models and technology. The need to harness technology to detect chemical, biological or radiological (CBR) agents and respond to threats is now in vivid focus for several U.S. cities. Real-time, accurate predictions of transport are in great demand by city, state, and federal agencies, and the UAO will make a major step toward establishing the utility and accuracy required. Sensor technologies are rushing to meet the needs of the anti-terrorist effort. Distributed networks of nuclear, biological and chemical sensors will rely on models and data synthesis for an integrated interdiction capability. BNL's vision is to (1) create advanced, science-based detector technologies, and (2) provide technical advice to first responders and front-line defenders. We will focus on New York City because we are neighbors. BNL has long supported New York City and New York State in four broad areas: (1) environmental impact including sludge analyses, acid deposition, and air [and water] quality; (2) consequence management activities; (3) infrastructure vulnerability and risk management studies; and (4) radiological expertise. We encourage strength through collaborations with balanced, synergistic contributions from partnerships.

Introduction

Hsi-Na (Sam) Lee, EML

We are gathered here today to discuss how we can improve; 1) our understanding of atmospheric turbulence caused by complex buildings in cities such as New York, and its effect on wind patterns and plume diffusion; 2) an atmospheric transport-diffusion model for urban scale prediction to support the Office of Emergency Management (OEM)of states and local cities in emergency response and planning. We will be specifically focusing on New York City (NYC) in this workshop. The objectives of this planning workshop are to; 1) plan to establish the intensive NYC meteorological observations and radiation detections used for emergency planning and evaluation of model prediction; 2) improve our understanding of atmospheric behavior over the urban area in Manhattan; 3) improve real-time urban model predictions and analyses, as well as data management; and 4) develop new methodologies and strategies to assist NYC's OEM in support of anti-terrorism efforts. I believe we have challenging and important tasks ahead of us, but I am sure that the collective thinking from all of you in this workshop will be the first step toward achieving success in our goal of protecting Americans.

Radiological/Nuclear Countermeasures Consequence Management

Michael Carter, Science & Technology, DHS Transition Office, U.S. Dept. of Homeland Security

Dr. Carter presented an overview of the new Department of Homeland Security, its current state and its vision for the near future. The DHS is continuing the activities of its inherited organizations and at the same time re-positioning itself to meet the new demands of increased terrorism and public vulnerability. Four major domestic Rad/Nuc initiatives were mentioned: radiological screening at our borders, intra-modal and perimeter detection, enhanced search and crisis response capabilities, and consequence management. The new department is developing a program in all of these areas and they welcome recommendations from the UAO scientists and engineers. Consequence management is a central issue and must support well-directed response, minimize casualties, and clean-up activities. Each of these activities requires detailed information on differing time scales, from minutes to days. And any modelling activity would need to incorporate emergency response information such as human dose distributions, weapon information, real-time incorporation of real-time observations. Modelling needs to incorporate the latest topology and population distribution fields. Population distribution fields need to represent real distributions at different times of the day, i.e. people are home at night and at work during the day.

A medical R&D program will reduce the immediate and long-term consequences of nuclear/radiological events. This program will work to develop new individualized dosimetry, tissue damage biomarkers, and new approaches to medical interventions. As the new technology advances, we will be able to offer effective early treatment to reduce acute and long-term effects of radiation exposure, as well as follow-up medical assessments and modeling of adverse health effects for population management and education.

A schedule for this activity is in development and depends on available resources but many tasks can begin now. However, a five-year road map was presented in which the vision for "Transport and Exposure Models" show the following:

Year 1: Review, assemble and integrate most scientifically defensible analytical models to completely and comprehensively address post-event transport and exposures.

Year 2: Improve the fidelity of transport and exposure models.

Keynote Address

Edward Gabriel, Deputy Commissioner for Preparedness,
The NYC Office of Emergency Management (OEM)
(rapporteur R. Michael Reynolds, Kevin Clark)

After a warm welcome, Mr. Gabriel described the history and activities of the New York City Office of Emergency Management (OEM). He reviewed the existing relationship between OEM and DOE/NNSA and the national laboratories, and thanked them for technical support and cooperation in the past. He said OEM would do everything possible to facilitate work in the area of developing better plume modeling because it is essential to his primary mission. It is of absolute importance for OEM to provide accurate guidance to the first responders who must enter a potentially dangerous region with almost no knowledge of the scope and type of the problem they will encounter. OEM personnel do not believe that the current generation of models will work optimally in the dense urban environment of New York City, especially in Manhattan. Thus, improvement of current models is essential because OEM must have confidence in the

Manhattan. Thus, improvement of current models is essential because OEM must have confidence in the accuracy of any plume model prediction before it will use such information to support its real-time decision making. A release of a chemical, biological airborne substance or radiation may be lethal within a specified area and "I will not send my people into an area to die."

NARAC Urban Modeling and the Local Integration of NARAC with Cities (LINC) Program

Gayle Sugiyama and John Nasstrom, Lawrence Livermore National Laboratory

DOE/NNSA's National Atmospheric Release Advisory Center (NARAC) at Lawrence Livermore National Laboratory (LLNL) provides predictions of the consequences of atmospheric releases of hazardous materials. NARAC has been operational for over 20 years, providing support for emergency response, pre-event planning, preparedness exercises, and consequence analysis. Recent NARAC applications include extensive support of post-September 11, 2001, DOE/DoD threat-response activities and the 2002 Salt Lake City Winter Olympics.

The foundation of NARAC is an integrated suite of research, development, and operational programs, focused on multi-scale meteorological and dispersion modeling, urban field experiments, and operational systems software (U.S. and global geographical databases, real-time meteorological data acquisition, chemical, biological, radiological and nuclear material property and health risk databases, graphical user interfaces). NARAC has recently developed urban canopy versions of its core diagnostic and numerical weather prediction models, as well as a computational fluid dynamics model, which explicitly resolves the effects of individual buildings. Participation in urban field experiments provides data to evaluate these models. NARAC is also developing and deploying its Internet client (NARAC iClient) and NARAC Web remote-access tools, which allow users to request and receive automated detailed predictions from the central facility at LLNL. The NARAC Web also provides a means for distributing NARAC products to multiple authorized users.

The objective of the Local Integration of NARAC With Cities (LINC) project is to demonstrate the capability for providing local government agencies with advanced, operational atmospheric plume prediction and situation awareness capabilities, which are seamlessly integrated with appropriate federal agency support for homeland security. NARAC provides customized modeling tools and release scenarios, local meteorological and geographical data, training for city and county system users, and operational support for exercises, special events and general emergencies. Seattle became the first LINC pilot city in FY2002 and New York was selected as a second LINC city during FY2003.

This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48. This work is supported by DOE/NNSA's Atmospheric Release Advisory Capability (ARAC) Program and DOE/DHS's Chemical and Biological National Security Program.

Previous Urban Boundary Layer Studies in New York City

Bob Bornstein, San Jose State University

This talk summarizes what was learned from previous studies of the structure of the polluted urban planetary boundary layer (PBL) over NYC. An extensive data set obtained in the late 60s as part of the NYU/NYC urban air quality study included: surface wind measurements at about 80 sites; surface sulfur dioxide concentrations at about 40 sites; 100s of (single, double, and double-double) pibal PBL wind profiles (that can be used to determine vertical velocity profiles); 100s of helicopter soundings of temperature, absolute humidity, and sulfur dioxide concentration; 50 (3-D) tetroon trajectories; and a sulfur dioxide emission inventory (on a grid a small as 1 km by 1 km). These data, analyzed at SJSU, have shown that NYC alters the PBL over and around it in a variety of ways, and that the resulting alterations greatly impact the spread of pollutants within it.

Upsets to the energy balance in the NYC urban boundary layer result from the radiative effects of pollutants and buildings, heat storage within the buildings, impermeable dry surfaces, and anthropogenic heat of combustion. These act to reduce nighttime cooling and to prevent formation of the nocturnal surface-based inversion normally found at nearby rural areas. A weak, shallow, elevated layer (at about 200-400 m) will, however, form over the city. This produces an urban heat island (UHI) that decreases with height over the lowest 300 m and a nocturnal urban boundary layer that is warm, polluted, and of near neutral stability. During windy conditions the urban PBL is plume shaped, while during calm conditions it is dome shaped. While urban surfaces show a strong surface daytime UHI, both urban and rural boundary layers have a near neutral stability, as heat is convected away from urban surfaces without interaction with the PBL.

As air traverses over a city it is changed in many ways, e.g., some of it will go over the city (mainly during daytime periods), some will diverge around the city (mainly during nighttime hours), and some will flow through the urban canyons. Some will also be entrained downward or inward into the canyons. During calm UHI periods, air will converge into the center of the city. The resulting pattern of upward and downward motions will be large (100s of meters) during daytime hours and smaller (10s of meters) during stable nighttime hours, with their magnitude limited by urban elevated inversions. Wind speeds increase into the city during UHI acceleration periods, while they decrease during non-UHI periods due to urban roughness induced deceleration. Turbulence levels are always increased over urban areas due to thermal production during UHI periods and mechanical production during non-UHI periods.

The processes that change the prevailing background flow over a city also effect the movement of synoptic and sea breeze frontals over NYC, i.e., their speed of movement is reduced during non-UHI periods and increased during UHI periods. In addition, moving thunderstorms are diverted around the city during non-UHI periods, while new thunderstorms are formed over the city from UHI-produced convergence.

These changes alter urban transport, diffusion, and removal patters in the NYC PBL. Pollutants released upwind of the city will not travel in a straight line through the city, but will advect around, over, and/or into the city canyons, while those released over the city will entrain downwind into some canyons (dependent on canyon geometry and wind direction). During otherwise calm UHI periods, urban-induced, inward-directed flows will first bring pollutants into the city and then loft them upwards.

For successful real time modeling of the release of toxic substances in or around NYC, it is imperative to first understand the concurrent, large-scale weather patterns and then the above-roof-top mesoscale flow patterns, as street canyon transport and dispersion is strongly influenced by these larger scale forcings. The NWS NYC area observational network is limited to about six surface sites and three rawinsonde sites, and its weather forecast models are run on regional scale grids and normally provide output only every six hours.

A number of other surface sites and mesocale networks, however, do exist in the NYC area, as do a few upper air sounders. In the near future, a 600 m TV tower will be built and instrumented across the Hudson River. It is thus necessary to insure that all the data from these sits are made available to the NYC UAO in real time. It would also be reasonable to re-analyze and archive the old NYU/NYC data for determination of their usefulness to understand the current NYC urban PBL. Mesoscale models (such as MM5 and RAMS) are currently run in a research mode at a variety of locations in the NYC area. It is necessary for these models to be run in a daily operational mode so that current mesoscale flow patterns are available as boundary conditions for the canyon scale dispersion models that must be used during a toxic release within the city. GIS and remotely sensed data could be used to provide input fields (e.g., of albedo and vegetative index) as the lower boundary conditions for the proposed modeling system

Thoughts on the Challenges of Establishing an Urban Atmospheric Observatory in New York City (Manhattan)

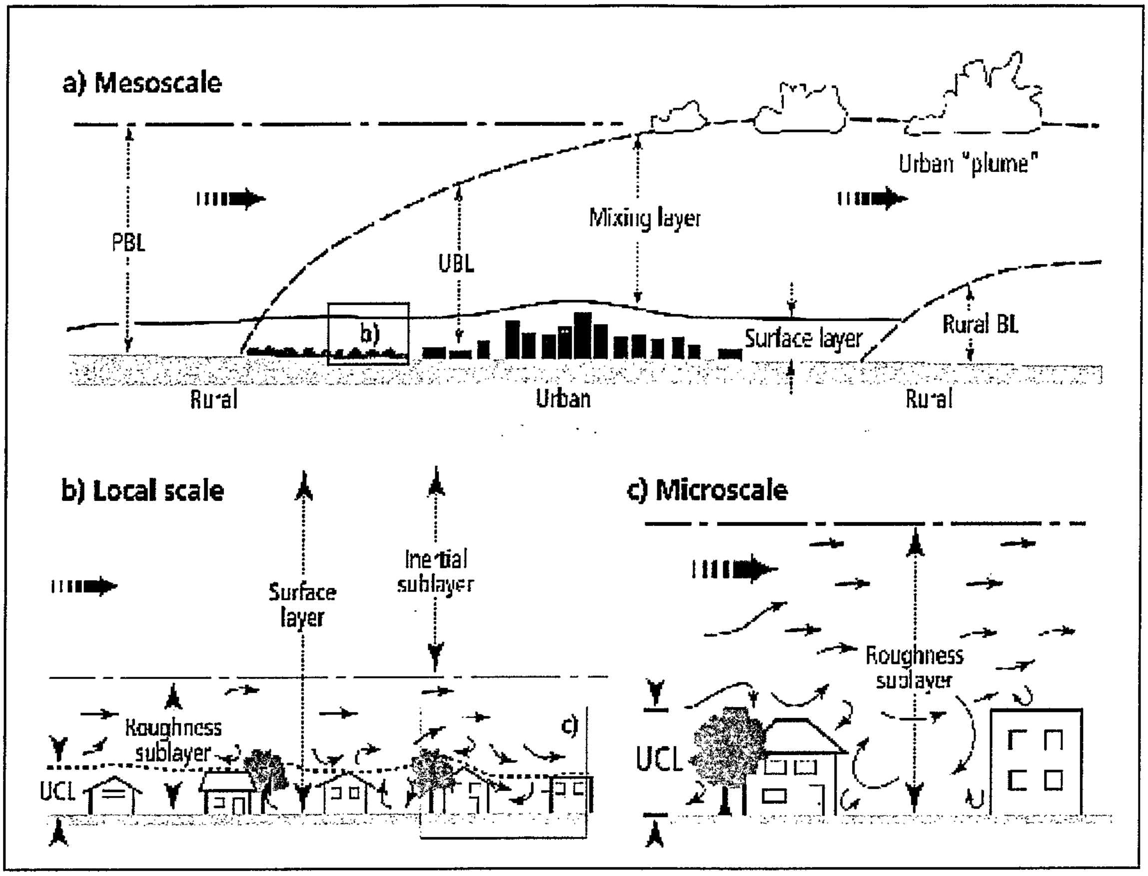
Tim R. Oke, University of British Columbia

The aim of this talk is to place the notion of establishing a semi-permanent urban atmospheric observatory (UAO) facility in the high-rise Manhattan district of New York City within the context of the present state of urban meteorology. Thereby it seeks to give a realistic assessment of the state of the science as a basis for understanding and modeling the urban atmosphere in such a densely developed urban environment. In particular, given that the Workshop objective is to give vision to the merits and design of such a facility, it emphasizes gaps in our understanding and limitations provided by existing theory and practice. A successful UAO must recognize these lacunae and difficulties so that it can help to improve the situation.

It is recognized that urban meteorology is relatively young and because of this and the inherent complexity of urban systems, it is not a fully predictive science. Although significant urban effects on climate have been observed for 200 years, the first numerical model to simulate them only appeared in 1964, and there are only about 20 years of work on the physical basis that could inform such models. On the other hand, the field is experiencing a surge of interest in the last 5 years; this is often driven by the need for models to accurately predict urban weather variables at several scales for use in calculations of dispersion, wind loading, energy and water conservation, heat island mitigation, human comfort and safety and weather forecasting for citizens.

As an introduction, both the chain of cause-and-effect formed by urban development interacting with atmospheric and surface processes, and the range of scales impacted (from micro- to global), are outlined. It is stressed that a full appreciation of the scale separations and their interactions is critical to the aims of the Workshop. This issue reverberates through theory, measurement and model design/assessment exercises. In all of these aspects modern approaches tend to rely on a degree of regularity or repetitiveness in surface geometry and cover at a certain scale. Without that it becomes very difficult to translate external forcings of radiation, wind, precipitation into the air layer beneath roof level (commonly called the urban canopy layer, UCL), where most interest lies. Whilst some degree of repetitiveness exists in high-rise districts like Manhattan, the effect of individual structures (buildings or blocks) introduces a strong element of uniqueness and even 'chaos', especially due to flow distortion. Such areas represent the 'Achilles heel' of the present state of urban meteorology – conversely, this constitutes a prime raison d'être for the establishment of the UAO, namely that it is needed to push forward the frontier of the subject. Manhattan is the quintessential high-rise district and its characteristics are mimicked in many of the great cities of the world. Places where people are concentrated but knowledge of their atmospheric environment is sparse – an unfortunate conjunction.

Some of the topics needing greater study are identified to include the 'barrier' effect of a great mass of buildings; the existence and relevance to dispersion of multiple stacked vortices; the impact of shadows on canyon convection; the significance of traffic-induced turbulence; the thermal and convective role of anthropogenic heat and vapor release from buildings and traffic; the nature of vertical profiles of wind, turbulence, temperature, humidity, and pollutants in canyons; the effect of the system on the vertical variation of visibility, low cloud and fog; the interaction between canyon air and that in buildings and subways through the 'honeycomb' fabric of the city; the applicability of similarity laws that are the basis of much of modern measurement and modeling. These are just some of the scientific challenges that need solution if understanding and the ability to build better models is to move forward.



Courtesy Tim Oke, University of British Columbia

The high-rise environment also poses several challenges to the design of both measurement networks in support of operational tasks, and the conceptual and practical creation of a world-class observational scientific facility. These include basic questions as to where to site and expose individual sensors so that they are optimal for the purpose and scale intended, and even more fundamentally, are we even able to place sensors in those spaces? The way to finding the solutions to such questions unfortunately often runs into the chicken-and-the-egg problem. To design the best placement requires that we know how the air behaves and properties are distributed, but we need the observations to know that. Whilst many standard measurement methods may be sufficient to probe the UCL, it seems probable that we need to encourage the development of new sensing systems (particularly remote sensing) to get the information needed at the scale wanted. Most remote sensors operate at the scale of the whole planetary boundary layer or even greater and cannot 'see' or give sufficiently detailed information in the UCL.

It is concluded that the challenges, both scientific and practical, are formidable but if turned into objectives for the UAO they are both much needed and attainable given vision and resources.

Overview of Urban Dispersion Models and Data Sets

Steve Hanna, George Mason University and Harvard School of Public Health

An overview is given of available urban dispersion models and data sets, covering the general research area over the past 40 years. The major boundary layer modifications in urban areas include increased turbulence and variability, decreased wind speed (light and variable in urban canopy), more occurrences of nearly-neutral stability, importance of thermal effects such as differential heating of buildings on sunny days with light winds, variations in the surface energy balance, and a lack of a single representative observing site.

Transport and dispersion model research was funded by chemical and biological agent (CB) concerns for several decades. The US had a CB offensive program through the Vietnam War and an extensive associated urban research program (e.g., the 1964-1966 Fort Wayne field study). In the 1970s and 1980s, the emphasis switched to EPA pollutants (e.g., NO_x, PM, toxics, lead, ozone, CO, SO_2) and concerns, including industrial point sources, area sources, and mobile sources in urban areas. There were many large EPA urban field experiments (two in St. Louis and several in Los Angeles and other areas with ozone problems) and model development efforts. The past five years has seen a switch back to DOD and DOE and CB concerns in urban areas.

Examples of urban dispersion models include:

- 1968 - McElroy-Pooler sigma curves based on 1963-1965 St. Louis tracer data
- 1968 - Csanady-Hilst urban model based on 1964-1966 Fort Wayne tracer data
- 1971 - ATDL simple model (Gaussian)
- 1973 – Briggs urban sigmas based on McElroy-Pooler and later incorporated in EPA's ISC-urban (Gaussian)
- 1983 – Ramsdell-Cramer-Hanna revised urban sigmas for Army
- 1980s - EPA Urban Airshed Model (UAM) – 3D Eulerian grid model with K's specified
- 1980s – Various street canyon models, such as the Yamartino-Weigand model
- 1980s – Many building downwash models such as reviewed by Hosker
- 1980s – EPA RAMS Gaussian model based on 1976 St. Louis RAPS data
- EPRI HPDM-urban (Gaussian with urban boundary layer parameterizations)
- 1990s – Urban Gaussian models using updated boundary layer parameters – OML, ADMS-urban, AERMOD-Urban, UDM
- Past 10 yrs – Many 3-D time dependent models (CFD of several types) for flow and dispersion around obstacles
- Recent "urbanization" of NARAC, HPAC, VLSTRACK
- Updated simple Gaussian and similarity models (e.g., revised AERMOD-Urban)

Early urban dispersion models used input data from a single meteorological monitor (e.g., NWS airport site or on-site tower). In the 1970s and 1980s, diagnostic wind models (interpolation among several observations plus a mass-conservation constraint) were developed and include LLNL MATTHEW and EPA CALMET. In the 1990s, NWP model outputs were used (but the grid was relatively coarse). Simple building recirculation effects were added to diagnostic wind models (e.g., Rockle-Kaplan-Dinar). The 2000s have seen improved grid resolution of NWP models. Advancements in computer speed and data assimilation have allowed development and application of real-time linked NWP and dispersion models (e.g., RAMS or OMEGA with HPAC, COAMPS with NARAC, MM5 with CMAQ). The past ten years have seen a great increase in the use of CFD flow models with fine grids (1 to 10 m) and development of improved parameterizations.

Many urban meteorology models have been developed, including early heat island models, canopy wind profile models such as Cionco and Davenport; surface energy balance models by Oke and Grimmond, and urban wind and turbulence profiles by Rotach. In addition to the combined urban meteorology and dispersion experiments already mentioned, urban meteorology field studies include the 1967 NYU/Bornstein NYC experiments, Oke et al.'s experiments in many cities, and Rotach et al.'s experiments in many European cities. There are concerns about how to handle meteorological inputs from multiple locations in an urban area. Because of variability and nonrepresentativeness there is much scatter observed in urban areas, as seen in the Salt Lake City Urban 2000 data.

Urban dispersion field studies include the 1964-1966 Army Fort Wayne study, the two EPA St. Louis studies (1963-1965 and 1976), the 1985 EPRI tall stack SF_6 tracer study in Indianapolis, and several large intensive regional ozone studies, many 1990s European urban street canyon studies, and recent tracer studies with releases within the urban obstacles in Birmingham (UK), Los Angeles, San Diego, and Salt Lake City (Urban-2000). The Joint Urban-2003 study in Oklahoma City is being planned.

The Army Fort Wayne study made use of a near-instantaneous line source from an aircraft flying over the upwind edge of a city at a height of 100 m. The EPA St. Louis study made use of a continuous point source near the ground in the urban area. Both studies had extensive monitoring networks out to about 10 to 15 km and detailed meteorological observations, including vertical profiles. There are many similarities in scientific issues and approaches between these 1960s studies and the new urban studies. However, there are some important differences between the old and the new urban dispersion field programs. The old experiments used fluorescent particles or SO_2 or other tracers that had problems with removal, while the new experiments use SF_6, PFs, or other conservative tracers. The old used bivanes for turbulence, while the new use networks of sonic anemometers. The old used *in situ* sensors, while the new use many remote sensors. The experiments at Fort Wayne and St. Louis included many intensive periods extending over several years and seasons, while the new experiments such as Urban 2000 tend to extend over a single multi-week intensive period.

Examples of recent urban dispersion field studies:

Birmingham, UK – Test of Perfluorocarbon (PF) tracers

- San Diego Barrio Logan – SF_6 tracer in Hispanic neighborhood (to address environmental justice issues, sponsored by California Air Resources Board)
- Los Angeles – SF_6 tracer in downtown, sponsored by Marines to test MIDAS-AT
- Salt Lake City Urban 2000 – SF_6 tracer in downtown, sponsored by DOE and DTRA
- Recent European Urban Experiments - There have been many urban flow and dispersion experiments in Europe in the past 10 years, but nearly all of them have involved routine air pollutants (e.g., NO_x) rather than tracer releases.

Examples of observed meteorological variability in the Salt Lake City Urban 2000 experiment were presented, with maps of instrument locations shown and examples of observed wind profiles. The wind data base included four sonic anemometers, all at 1.5 m agl around a building near the source location, and these instruments usually reported light and variable winds at 0.5 to 1 m/s. The data base also included seven cup anemometers located on buildings at elevations agl of about 7 m to 124. In addition, the wind observation at the SLC airport at 10 m agl was included, as well as at an upwind rural site at 10 m agl. The wind data from the fixed anemometers were augmented by data from three remote sounders – two at the upwind site and one on the roof of a downtown building. It was shown that the urban observations could be fit, with agreement within plus and minus 20 to 30 %, by a simple log-linear wind profile formula, as long as the surface roughness length (2 m) and displacement length (10 m) were prescribed, and the Britter formula for the characteristic velocity in the urban canopy layer was used.

Dispersion Modeling of Airborne Chem-Bio Agent Terrorist Attacks in Cities

Michael Brown, Los Alamos National Laboratory

The presentation covered modeling approaches for urban dispersion problems. The talk emphasized the need for different levels of model fidelity for different types of applications. For example, some applications might require a more accurate answer (e.g., a vulnerability assessment of a particular building or facility), some applications might require a quick turn-around time (e.g., emergency response scenarios). Two models were highlighted that were developed at Los Alamos National Laboratory: a high fidelity computational fluid dynamics/meteorological large eddy simulation (LES) code called HIGRAD and a fast response empirical/diagnostic code called QWIC-URB. Both codes produce 3D wind fields around explicitly resolved buildings, but the former solves a full set of fluid dynamic and thermodynamic equations, while the latter uses empirical equations and mass conservation. HIGRAD requires multi-processor computing platforms, while QWIC-URB requires a laptop and runs in tens of seconds. HIGRAD, being an LES code, has the advantage of being able to simulate the real-time stochastic behavior of plumes, that is, concentration fluctuations. The QWIC modeling system only produces the mean concentration field. The QWIC modeling system has the advantage of being easily able to ingest real-time meteorological data. One could envision this code running around the clock using the NYC UAO wind measurements as input, producing 3D wind fields around the buildings in NYC every minute or so. For HIGRAD, we envision creating a library of wind fields for a particular site (e.g., Lower Manhattan) that can be accessed in real time through a graphical user interface and can be used with a fast running dispersion model. The QWIC modeling system is being used as part of a SENSOR SITING tool, and a graphical user interface has been developed for setting up the problem, running the wind model, running the dispersion model, and then visualizing output in 2D or 3D.

Operational Forecasting of Atmospheric Transport on the Scales of Metropolitan Areas

Tom Warner, NCAR

There are three main themes to the material discussed. One is that operational prediction of transport and dispersion (T&D) in metropolitan areas with coupled meteorological and T&D models is currently feasible. This capability is illustrated by the operational MM5-SCIPUFF predictions that were produced for over 100 days during the Salt Lake City Winter Olympics in 2002. Twelve-hour forecasts were produced every three hours using a quadruply nested MM5 grid system with a 1.3 km fine grid centered over Salt Lake City and the Olympic venues. These forecasts were used by DoD for emergency-response planning and training, and would have been used for actual emergency response had an incident occurred.

The meteorological-model forecasts for the Olympics period were compared with observations, with an emphasis on the low-level winds. It was shown that MM5 captured the local orographically forced diurnal wind circulations, but that the MM5 object skill statistics for the winds (as, for example, reflected in the mean absolute error or bias) were only marginally better than those from much coarser-resolution NWS models that had no mesoscale structure to the solution. This illustrates the need for developing improved methods for assessing model skill at forecasting low-level winds that are required as input for T&D models.

Ensemble techniques were shown to have benefit for coupled meteorological and T&D calculations. The resulting probabilistic information about dosages and concentrations will be valuable for decision makers that need to allow for the fact that model forecasts are far from perfect.

Lastly, it was shown that the operationally available winds from the NWS Doppler radars could be assimilated into a simple atmospheric model using four-dimensional variational techniques. These high-resolution radar winds are combined with other wind data by the model, and a dynamically consisten,t high-resolution, boundary-layer wind field can be produced operationally within a few minutes of elapsed time. These winds were used to drive SCIPUFF in a demonstration.

Simulation of Toxic Air Pollutants Released in Urban Areas

Alan Huber, Environmental Protection Agency

Understanding the pathway of toxic air pollutants from source to human exposure in urban areas is of ongoing interest to the US Environmental Protection Agency. This same research and development has application in supporting Homeland Security in that one person's accident could be a terrorist's plan. The collapse of the New York World Trade Center (WTC) towers increased EPA/ORD's awareness that there is a serious scientific shortcoming when it is necessary to do exposure and risk analyses of a specific air pollution event in order to inform the local officials and the public. The scientific shortcoming is even more serious when the air pollution events occur in an urban center where the understanding of airflow around large buildings is poor. Using current high performance computing technology, applications of

Computational Fluid Dynamics (CFD) and Scientific Visualization are being used to provide understanding of the complex air flow in urban environments and the consequences of pollutant emissions carried by this air flow. There are scientific challenges in developing reliable simulations of airflow in urban areas with large buildings. CFD simulations have the ability of closely matching the true geometry of the buildings and the "real world" physical processes. CFD simulations can be used to study actual events to gain insight into what happened or study perceived events to understand what could happen. The understanding from applications of CFD simulations or events can be used directly or be used as a foundation for developing reliable simplified models. Scientific Visualization transform the information from CFD simulations into the geometric, enabling one to observe the computations. Visualization communicates information in ways that are easily understood. CFD simulations provide the information which then is visualized to provide understanding. Pilot study applications of CFD simulations and Scientific Visualization were ongoing in an area in Midtown Manhattan prior to September 11, 2001. However, developments are now being redirected to Lower Manhattan and accelerated to support the reconstruction of the smoke/dust plume following the collapse of the WTC towers. Examples of progress are presented now to demonstrate the process of setting up a CFD simulation. Building geometry for most US Cities is available from several commercial and governmental sources. Data from Vexcel Corporation was used to develop the present model of lower Manhattan. Commercial CFD software from Fluent, Inc. is being used to develop the simulations. Applicable field measurements and measurements from a scaled model study at EPA's Fluid Modeling Facility are being used to provide evaluations of the CFD simulations. There are challenges in pushing the temporal and spatial scales of events that may be practically computed using today's technology. However, today's frontiers will be expanding rapidly with tomorrow's technology. Events that cannot be calculated in real time may be precalculated and readied to support emergency response and management, or used to support the development of reliable simplified models that may be used in real time. With expanding computing resources, EPA science through its research and development program will make Environmental CFD simulations a valued tool in improving the understanding of human exposures and risks to environmental pollutants, be they from routine emissions, accidents or a terrorists plan.

Defense Threat Reduction Agency (DTRA) Urban Dispersion Modeling Program Overview

John Pace, DTRA/TDOC

Mr. Pace gave an overview of the DTRA program to develop urban-scale wind and dispersion models, and to integrate them into DTRA's Hazard Prediction and Assessment Capability (HPAC). Mr. Pace demonstrated this system by starting an urban HPAC execution for a chem-bio weapon release in New York City at the beginning of his presentation. The model ran while Mr. Pace gave his presentation, and he showed the output following his discussion of the program. (The output from this run is now inserted into the powerpoint presentation.) To Mr. Pace's knowledge, this is the only operational dispersion modeling system with fully-integrated urban-scale wind and dispersion models.

The current urban HPAC system incorporates two urban-scale models. The first is the Urban Windfield Module, developed by Titan Research. The UWM calculates urban wind patterns by introducing bulk drag caused by buildings into a coarse CFD model. The model runs very quickly and provides a reasonably good steady-state depiction of urban-scale winds.

The second model is the Urban Dispersion Model developed by the Defence Science and Technology Laboratory of the UK Ministry of Defence. The UDM is an empirical model showing dispersion patterns inside a city based on the relationships developed from wind tunnel and scaled field studies.

A key feature of this system is the linkage between the UDM and the dispersion model used by HPAC for non-urban situations, the Second-Order Integrated Puff model, SCIPUFF. As released material moves above the urban canopy or outside the urban domain, it is transferred to SCIPUFF for further handling. This coupling enables urban HPAC to calculate inside-city dispersion as well as downwind effects, without any break in the calculation or need by the user to link two models manually. The integration of the UWM and UDM within HPAC allows the user to run either of these urban models, or both of them, or neither, depending on the situation and operational constraints.

Mr. Pace showed slides illustrating the functions of the UWM and UDM. Also he discussed two additional exterior urban dispersion models not yet incorporated in HPAC, as well as the COMIS building interior model which is now being integrated into HPAC. When included inside HPAC, COMIS will calculate dispersion from room to room within buildings, as well as infiltration and exfiltration causing exchange of material between the building and the outside environment.

Urban dispersion models require data describing the actual buildings in the city of interest, and DTRA has established a link with the National Imagery and Mapping Agency to acquire building data in the proper format for use in urban HPAC. These data can be shared with any other government dispersion modeling organization.

DTRA supports and leads a variety of field exercises to acquire data for dispersion model development and validation, including the Mock Urban Setting Test (MUST) at Dugway Proving Grounds in September 2001, a building interior dispersion experiment in Salt Lake City in May and June 2002, and a major field study in Oklahoma City in July 2003 (joint with DOE's CBNP program) called the Joint Urban 2003 study. Validation of the UWM, UDM, and the coupled urban HPAC system shows good results to date, and DTRA is having an independent verification and validation study accomplished this spring to evaluate the current system thoroughly.

NYC Map: A Digital Model of New York City

Sean Ahearn, Hunter College
(rapporteur R. Michael Reynolds)

Dr. Ahearn, director of the Center for the Analysis and Research of Spatial Information (CARSI) of Hunter College, presented an overall description of the NYC Geographical Information System (GIS) which is central to emergency management activities. The GIS, called NYCMap (pronounced "nice map"), a database of highly detailed geographic information on the entire city, accurate to within 18 inches. NYCMap is part of a broader effort involving the city's Office of Emergency Management Mapping and Data Center. It was created over a period of five years, and was a joint project of DoITT, the Department of Environmental Protection, and Hunter's CARSI lab. The NYCMap should provide an excellent source of topography and geometry to support modelling activities on all scales. A new aerial photogrammetric study is being incorporated into the GIS and will yield three-dimensional resolutions to 0.3 m resolution.

NYC Subway Dispersion and Above/below Ground Interactions

David Brown/Tony Policastro, Argonne National Laboratory

The discussion of subway modeling and experiments is broken into three key topics: (1) subway transport and fate model; (2) characterization of natural flows (i.e., subway system flows driven by above ground meteorology); and (3) analysis of the NYC subway system in the mid-Manhattan area and the 1966 biosimulant experiments. The subway modeling background describes two models and the key driving forces affecting transport and dispersion. The first model is a detailed subway systems model based on the Subway Environment Simulation code. This model has been further developed and used extensively by ANL in vulnerability assessments and response strategy development. The second is a rapid response model for use in time-critical applications. This model predicts C/B agent concentrations within the subway system and emission of such materials to street level due to the action of train- induced flows, natural subway system flows, and transport within train cars. This latter model is currently employed in a real-time crisis management system in Washington, DC within the PROTECT program. The second topic, characterization of natural flows, outlines this critical component to modeling subway transport and dispersion. These flows can be as important as train-induced flows when trains are operating. More importantly, however, if a release is suspected, subway operators will stop the trains, leaving natural flows as the sole transport mechanism. We describe the current experimental program in Washington for understanding these flows. This experimental program includes (1) continuous sampling of flows, temperature and pressure at 10 locations within the tunnel system; (2) collection of temperature data at 29 additional in-station locations; and (3) periodic measurement of flows at entrances to several subway stations during normal operation. Preliminary results show that significant natural flows are present through the test area both during normal train operation and when trains are stopped. Flows respond to external meteorology through a combination of outside-to-subway temperature differences and wind-driven pressure effects caused by the presence of buildings. In particular, large outside-to-subway temperature differences (with the outside colder) are associated with higher in-tunnel velocities. These same experimental techniques can be easily applied to the UAO study to greatly further the understanding of natural flows and determine if the flow effects observed in Washington apply to New York.

The third topic is a background on the NYC subway system in the Manhattan area. This discussion details unique aspects of the NYC system, such as complexity and size of the system, and use of express trains and four track tunnels. The 1966 biosimulant experiments are described, along with general observations relating to contaminant transport and fate in three Manhattan subway lines. Three of the five experiments were conducted in the portion of the subway system within the proposed study area, making their analysis important to the overall efforts in understanding subway system flows and their impact on the above-ground environment.

SensorNet: Common Data Highway for Incident Management

Brian Worley, Oak Ridge National Laboratory

SensorNet is the Information Technology (IT) infrastructure of a national system for comprehensive incident management in cooperation with state and local governments. This IT infrastructure provides a common data highway for a comprehensive set of homeland-security sensors that includes, but is not limited to, Chemical-Biological-Radiation-Nuclear-Explosive (CBRNE) sensors, meteorological instruments, and other sensors (i.e. video cameras, air quality, environmental, etc.). The SensorNet infrastructure architecture allows distributed access with multi-level security, information fusion, and a common operational picture. The system is designed to assure an ultra-high level of reliability, survivability and security. The architecture is scalable across state, local, and federal governments.

DCNet: Meteorological Monitoring Network for Washington, DC – Initial Observations

Will Pendergrass, NOAA

A high-resolution meteorological monitoring network (DCNet) is being developed for the urbanized area of Washington, DC. The intent is to provide sufficient meteorological monitoring capability to resolve significant features of the urban wind field. The proposed network would consist of approximately 150 surface meteorological monitoring stations, supplemented with a network (8) of upper air (surface to 3km) sampling stations. This monitoring network would provide a routine, three-dimensional, meteorological framework of current wind and temperature conditions over the Washington, DC metropolitan region (Washington, DC and suburbs). This intensive network would be routinely sampled, with observations supplied to the National Weather Service for dissemination to both civilian and government agencies. An anticipated product of the monitoring/modeling system would include real-time displays of current meteorology, output from a diagnostic meteorological model, output from a prognostic model, and impact projections from a coupled chemical/biological dispersion model. This information could be provided in real-time to various situation rooms in the Washington, DC area. Currently twelve stations are operating in the DC area with three more planned for telephone cell towers in the coming months. Data are available with a 15-min update from a secure web site. Plans to feed the data to NARAC and to the NOAA HYSPLIT model are underway. Data thus far show extreme local variability in wind speeds and directions, which would severely impact dispersion calculations. However, turbulence data indicate much less effect from building-induced circulations than would have been expected. It is believed that rooftop measurements, only 10 m above the roof, have reliable turbulence indicators that could be used in real-time dispersion models.

The Urban Atmospheric Observatory (UAO) Pilot Experiment at NYC

R. *Michael Reynolds, BNL*

Brookhaven National Laboratory, in collaboration with the Department of Energy's Environmental Measurements Laboratory (EML) in Manhattan, is beginning a long measurement exercise at the EML building at the corner of Houston Street and Varick Avenue. This exercise will be a preliminary to the larger Urban Atmospheric Observatory (UAO), which will be staged further in midtown. The pilot measurement exercise will begin as soon as possible. Meteorological stations will be provided by the National Oceanic & Atmospheric Administration (NOAA) Air Resources Laboratory (ARL) and BNL. BNL will provide instrumentation for measuring winds, pressure, temperature, and relative humidity at two levels and four locations along intersecting urban canyons. The winds will be measured by three-dimensional, high-speed, sonic anemometers.

Both BNL and EML will contribute to the pilot experiment. BNL will provide instrumentation and EML will provide data ingest and dissemination. The purpose of the pilot exercise is (1) to gain experience in deployments in the Manhattan area, (2) to evaluate the spatial variability in dispersion-significant winds throughout the year as the basis for a proposal for the UAO, and (3) to have a real data scenario with which to develop preliminary dissemination tools, further strengthening our intended UAO proposal.

EML Pilot Studies for the Urban Atmospheric Observatory

Hsi-Na (Sam) Lee, EML

In response to the disaster at the World Trade Center (WTC), EML located in lower Manhattan has initiated three pilot studies. (1) An aerosol sampling system was installed on the roof of EML to characterize the passage of atmospheric plumes over EML. (2) A meteorological station that provided mean pressure, temperature, wind speed, wind direction, and relative humidity. (3) A prototype radiation monitoring platform by including a Comprehensive Radiation Sensor (CRS) on the roof of EML to characterize the radiation background.

The aerosol system provides a continuous background measurement of the aerosol composition measured on the roof that could provide a reference aerosol measurement in case of potential future disasters. The system is presently designed to control a single cascade impactor and a single 47 mm filter sampling through a PM10 inlet. The impactor provides a continuous measurement of atmospheric aerosol in two size ranges (0.2 to 2.5 μm and 2.5 μm to 10 μm). A final filter collects particles below 0.2 μm. The filter provides a PM10 ambient air concentration measurement.

The Comprehensive Radiation Sensor (CRS) characterizes the radiation background. In the case of a nuclear event, a radiation sensor is required to quickly detect the radioactive cloud. A network of such radiation sensors would provide information on the movement of a radioactive cloud (see Colin Sanderson abstract.)

In summary, rooftop wind measurements must be related to the larger scale atmospheric flow in order to predict plume transport. The aerosol sampling system detected more than 25 plumes passing over EML.

A Comprehensive Radiation Sensor System for Homeland Security

Colin Sanderson, EML

The Comprehensive Radiation Sensor (CRS), a gamma radiation detector and spectroscopic analyzer, was developed by EML as an ideal instrument for a "Homeland Security Radiological Network." The CRS responds within 2 seconds of detecting an elevated radiation level, alerting nearby personnel and sending out a network alarm, which can allow immediate intervention. The combination of rapid sampling and high sensitivity, which makes it an ideal Area Monitor, permits it to quickly detect any radioactive cloud. A network of many CRS units, linked together and connected to a central station, can provide wide geographic coverage, and also allow tracking the movement of these clouds. In addition, CRS units can serve as low-cost Portal Monitors at bridge and tunnel entrances or border entry points.

The CRS also supplies spectral data to identify the detected radioactive material and distinguish between natural and anthropomorphic radioactivity. This information is useful in minimizing radiological health effects and planning for effective remediation. (For example, by identifying a radioactive release as isotopic iodine, protection against damaging thyroid uptake is possible by taking potassium iodide pills.)

The CRS is economical, uses off-the-shelf components, needs minimal maintenance, and thus is inherently reliable. A unit installed on a rooftop in Manhattan has supplied over 40,000 spectra since November 2001 without interruption. A wireless CRS network, using commercial cell phones and service providers, is being developed and should offer a cost effective, easily implemented networking system. Several special versions of the CRS are also being developed, such as a totally contained "Lampost" unit, using a Pocket PC and cell phone for communication, and designed for unattended locations. Another type of CRS will be designed for automobile use, such as in Police cars or other emergency vehicles.

Real-time Display of EML Network Data

Richard Larsen, EML

EML has designed and constructed a radiation monitoring station on its buildings roof. This station serves as a prototype for the planned EML network of radiation sensors to be deployed in Manhattan. Data from two of these sensors (pressurized ionization chamber and a Comprehensive Radiation Sensor) are displayed on the Internet in real-time. Historical data from these sensors is also made available electronically over the Internet by using an Internet form. EML collaborated with the Environmental Systems Research Institute (ESRI) to develop a demonstration of a GIS visualization of a multi-sensor environment. The sensors are represented as symbols (colored circles) on a base street map of Manhattan. The color of each symbol (sensor) depends on its current data output, varying from green (low activity) to red (high activity). This GIS application, accessible over the Internet, includes both zoom and pan features. In addition, the GIS can also display the output from a Gaussian plume model as a transparent thematic layer on the base Manhattan street map. EML collaborated with Urban Data Solutions in New York City to investigate techniques for 3-D visualizations of measurement data in Manhattan. Urban Data Solutions has mapped the Manhattan buildings in 3-D from 72nd Street to the Battery with 1 meter resolution.

The New Jersey Tower (The Observatory for Weather & Environmental Research)

Alan Robock, Rutgers University

The Metropolitan Television Alliance is planning to build a 2000 ft (610 m) TV tower in New Jersey across from New York City in the next two years. We will work with them to instrument this tower at several levels to make it into a unique vertical environmental observatory. The observations will allow us to work on the following projects:

1. Monitoring weather and climate
2. Measuring pollution
3. Homeland security
4. Wind shear detection for Newark and LaGuardia airports
5. Regional climate modeling
6. Educational displays on the Web and at the Liberty Science Center

The elements to be measured will include: wind speed and direction, temperature, humidity, upward and downward shortwave and longwave radiation, aerosols, ozone, nitrogen oxides, carbon monoxide, carbon dioxide, organics, biological materials, and mercury.

The tower will have room guest investigators for additional instruments that will be developed in the future and for intensive field campaigns. We are currently in the design phase of this project.

Group photo of participants to the workshop on the 12th floor roof of EML. From left to right: David Brown, Tom Warner, Tim Oke, Gayle Sugiyama, John Nasstrom, Alan Huber, Tom Graham, Alan Robock, Sharon Zuhoski, Michael Reynolds, George Hendrey, Joanna Grossman, James McConnell, Steve Hanna, Hsi-Na Lee, Brian Worley, Rick Wagener, John Pace, Tony Policastro, Robert Bornstein, Ron Cionco, Michael Brown.

Acknowledgements

The authors, R. Michael Reynolds of BNL and Hsi-Na (Sam) Lee of EML, wish to acknowledge the many researchers and administrators who encouraged formation of the workshop and the Urban Atmospheric Observatory concept. In particular, Bruce Hicks of the NOAA Air Resources Laboratory and John Pace of Defense Threat Reduction Agency provided excellent advice on key researchers who were instrumental in the success of the workshop. Three key academicians, Robert Bornstein of San Jose State University, Tim Oke of University of British Columbia, and Steve Hanna of George Mason University, provided the best possible grounding on which the UAO was developed and on which it will continue to grow. A strong positive support from the New York City Office of Emergency Management emphasized the necessary balance between real-time, emergency management needs and the scientific advances that will occur on a longer time scale. In particular, Edward Gabriel and Kevin Clark from OEM are thanked. The authors extend their gratitude to Michael Carter of Science & Technology in the Department of Homeland Security for attending this workshop in spite of a busy schedule. Also, thanks to Mitchell Erickson, Director of EML and Ralph James, Associate Director of BNL for their support. Finally, the program organizers, Sharon Zuhoski of BNL and Rita Rosen and Kevin Clancy of EML, are acknowledged for their terrific efforts.

APPENDIX I: Urban Atmospheric Observatory (UAO) First Planning Workshop Agenda

27 January 2003

08:30	Opening and Welcome, Mitchell D. Erickson, Director of EML
08:45	Welcome, Ralph James, Associate Laboratory Directory for Energy, Environment & National Security (EENS), BNL
09:00	Introduction, Hsi-Na (Sam) Lee, EML
09:10	Announcements, notices, lunch plans, etc. Michael Reynolds, BNL
09:15	**"Radiological/Nuclear Countermeasures Consequence Management"**, Michael Carter, Science & Technology, DHS Transition Office, U.S. Dept. of Homeland Security
09:30	Keynote address, Edward Gabriel, Deputy Commissioner for Preparedness, The NYC Office of Emergency Management (OEM)
09:55	**"NARAC Urban Modeling and the Local Integration of NARAC with Cities (LINC) Program"** - Gayle Sugiyama/John Nasstrom, NARAC
10:10	**Coffee Break**
10:30	**"Observation and simulation of the polluted urban coastal boundary over NYC"** - Bob Bornstein, San Jose State University
11:00	**"Thoughts on the challenge of establishing an Urban Atmospheric Observatory in NY Manhattan"**-Tim Oke, University of British Columbia
11:30	**"Overview of urban dispersion models and data sets"** - Steve Hanna, George Mason University
12:00	**Lunch**
13:00	**"Dispersion Modeling of Airborne Chem-Bio Agent Terrorist Attacks in Cities"** - Michael Brown, Los Alamos National Laboratory
13:30	**"Operational Forecasting of Atmospheric Transport on the Scales of Metropolitan Areas"** - Tom Warner, NCAR
14:00	**"Manhattan modeling in support of EPA assessments following 9/11/2001"** - Alan Huber, Environmental Protection Agency

14:30	**"Defense Threat Reduction Agency (DTRA) Urban dispersion modeling program"** - John Pace, DTRA/TDOC
15:00	**Coffee Break**
15:30	**"NYC Map: A digital model of New York City"** - Sean Ahearn, Hunter College
16:00	**"NYC subway dispersion and above/below ground interactions"** – David Brown/ Tony Policastro, Argonne National Laboratory
16:30	**"SensorNet: Common data highway for incident management"** - Brian Worley, Oak Ridge National Laboratory
17:00	**"DCNet: Meteorological monitoring network for Washington, DC – initial observations"** – Will Pendergrass, NOAA
17:20	**"The Urban Atmospheric Observatory (UAO) Pilot Experiment at NYC"** - Michael Reynolds, BNL
17:30	**"EML Pilot Studies for the Urban Atmospheric Observatory"** – Hsi-Na (Sam) Lee, EML
17:40	**"A Comprehensive Radiation Sensor system for Homeland Security",** – Colin Sanderson, EML
17:50	**"Real-time Display of EML Network Data"** – Richard Larsen, EML
18:05	**"The New Jersey Tower (The Observatory for Weather & Environmental Research)"** - Alan Robock, Rutgers University
18:15	Wrap-up and closing comments – Michael Reynolds, BNL

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28 January 2003 – SCIENTIST'S WORKSHOP

Begin the process of developing an initiative and designing the UAO plan

09:00	The concept: what do we mean by a test bed, long-term measurements, instrumentation network? Scientific study areas. Moderator: Steve Hanna
10:15	**Coffee Break**
10:30	The desired study area selected. Moderator: Bob Bornstein
12:00	**Lunch** – Tour EML's roof (instrumentation related to pilot, etc.) and view NYC

13:30	Instrumentation, goals of the measurements, density of observations. Moderator: Tim Oke
14:45	Data collection, external data, OEM pipeline. Moderator: Rick Wagener
15:45	**Coffee Break**
16:00	Intensive operation in 2004 or 2005? Costs. Moderator: Michael Reynolds
16:30	Follow-on open workshop. When, Where, Objectives? Moderator: Hsi-Na (Sam) Lee
17:00	Plans for workshop report and initiative. Schedule. Moderators: Michael Reynolds and Hsi-Na (Sam) Lee
17:15	Closing and wrap-up. Hsi-Na (Sam) Lee

APPENDIX II: Urban Atmospheric Observatory (UAO) First Planning Workshop Attendees

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