Efforts to bridge gap between fundamental atmospheric research and national security at BNL

Presented by Martin Schoonen
Associate Laboratory Director
The Importance of the First Hour in an Event

- For First Responders the first hour of an event is critical.
- One of the most important decisions is to determine whether to evacuate or shelter in place.
- If evacuation is necessary, need to define area based on urban dispersion model projection.
- Need to update projections with on-the-ground information/measurements.
Urban Dispersion Modeling Challenge

- Estimate source term based on incomplete information
  - Radiological device
  - Chem-Bio
  - Street level or underground

- Dispersion is difficult to project as it is subject to:
  - Regional weather pattern (e.g., on-shore vs off-shore wind)
  - Coupling between atmospheric and oceanic systems
  - Complexity induced by urban canopy
  - Exchange of air with subway system and buildings
  - Traffic movement (intensity and directions)
- Part of DOE
- Responsible for modeling dispersion
- Capability to conduct urban dispersion modeling
- Need observations to improve model projections
Atmospheric System Research at BNL: Influences of Aerosols and Clouds on Climate and Climate Forcing

Goal improving climate predictions
Major Contributor to ARM
- design and build of mobile aerosol laboratories
- instrument development
- radar data analysis & retrievals
- support long-term measurements as well as campaigns
- conduct Large Eddy Simulations (with PNNL)
- lead External Data Center and ARM metadata management

Supporting Atmospheric Radiation Measurement Climate Research Facility
Challenge

- No DOE fundamental research aimed at urban systems
- Typical deployments require lots of space and last as much as two years
- Focus on cloud life cycle and role of aerosols at > 100 m spatial scales
- NARAC does not lead field studies.

- "Terrorist attack cities rather than corn fields and they prefer cloudless days"
- DOE radar equipment not optimized for “clear air” observations and not nimble.
- Need data to improve “skill” of urban dispersion model projections, particularly regional weather system-urban coupling and fine scale perturbations as a result of urban infrastructure
Gap: Lack of comprehensive understanding of urban ventilation (large scale regional weather system urban coupling problem)

- Understanding and modeling the ventilation of urban centers requires comprehensive multi-scale wind measurements.
- Phased-array radars and long range Doppler lidars require nearly zero infrastructure and are easy to deploy in urban areas where real estate is expensive or simply not available.

(Courtesy Pavlos Kollias)
Remote Sensing Techniques for Measuring 3D Winds in Urban/Coastal Environment

Scattering mechanism: Aerosols in the lowest 2 km of the planetary boundary layer

- Requires scanning **Doppler lidar** technology
- Advantage: No ground-clutter, provides canyon/street level wind
- Typical range: 2 -15 km but very high resolution
- Conditions: Clear skies

Scattering mechanism: Chaff (used as air tracer)

- Requires a short-range (X-band) scanning **phased-array** radar
- Advantage: Long range (20-40 km)
- Disadvantage: Will provide measurements 100 m above highest structures (due to ground clutter)
- Conditions: Clear skies (chaff), precipitation (hydrometeor scattering)

Scattering mechanism: Coherent (Bragg) scattering due to temp/humidity inhomogeneities

- Requires a long-range (S-band, like NEXRAD) scanning radar
- Requires an S-band radar at the right place and distance from area of interest (mobile?)
- Advantage: Long range (30-50 km)
- Conditions: Clear skies, precipitation (hydrometeor scattering)
Long-range Doppler lidar

Mobile Doppler lidar:
- High power
- Long range (10 km)
- Scanning

Mounted on mobil radar truck.

Transfer from DoD (Navy) to Brookhaven National Laboratory
Boundary layer dynamics over London, UK, as observed using Doppler lidar during REPARTEE-II (Barlow et al, 2011)
BNL lidar range: 6-8 miles
Low power lidars: 1.5 - 2.0 miles
Low-power Phased Array Radar (LPAR) - Raytheon

- Weather radar (X-band)
- Fast scanning
- Polarimetric

Installation options:
- Truck mount
- Roof mount
- Building / Cell Tower Mount

- Long-term bailment agreement between Raytheon and SBU in place
- Requires mechanism to deploy chaff to study clear air conditions

Requires only power & Ethernet Direct laptop connection allows for remote operation
MWR-05XP (Owned by CIRPAS/NPS)

- Phased-array X-band radar
- Fast scanning
- Mobile (truck included)
- Very sensitive
  - -25 dBZ @ 10 km
- Robust, weatherized military version
- Chaff to track turbulence in clear air

Transfer from DoD (Navy) to Brookhaven National Laboratory
Addressing smaller scale influences

To improve fine-scale "skill" of urban dispersion models we need a range of tracers that provide “test” data for modeling community under well-characterized, regional-scale weather conditions.

Possible tracers:
- “accidental” near-continuous release of gaseous tracers (e.g. leakage of coolants, NYU, Dr. Masoud Ghandehari)
- gaseous tracer experiments
- tagged synthetic particulate tracers as proxies for aerosols

Direct spectroscopic observations (NYU studies)

Release, sample, analyze strategies

Desired End Result:

*Establish detailed flow patterns under well-characterized conditions on the basis of dispersion of tracers*
Particulate tracers (e.g., DNATrax)

www.safetraces.com
Perfluorocarbon Tracer (PFT) Technology

- Developed at Brookhaven National Laboratory in the early 1980s
- Testing atmospheric transport and dispersion models
- Building infiltration
- Underground systems
- Mass transfer in multiple research and engineering applications
- Six to ten tracer compounds available allowing multiple experiments to be conducted simultaneously
Why do perfluorocarbon compounds make good tracers?

- These compounds are:
  - chemically inert,
  - non-flammable,
  - have no biological effects.

- Low background levels

- Detectable at these low levels

- 6 to 10 compounds available which can be resolved in a single analysis so multiple experiments can be conducted with each set of samples
Brookhaven PFT Technology

- Samples collected on an activated charcoal adsorbent
- New, state-of-the-art programmable samplers and analytical equipment
- All seven compounds can be resolved in a single analysis
  - Multiple experiments for each set of samples
  - Flexibility to address complex questions by releasing multiple tracers during each experiment
  - High level of QA/QC
- Lab or Real-time field capability
Previous Sponsors

- DHS (UDP in NYC, London Underground study, current UTR study in NYC)
- NYPD (S-SAFE study in NYC)
- DTRA (UDP)
- Pentagon (CCUTS study)
- U.S. Navy
- U.S. EPA
- Nuclear Power Plants (control room studies)
Possible Strategy to Improve Model Projections for NYC (Integrate High-Resolution Modeling and Observational Strengths)

- Conduct detailed observations over a range of weather patterns that represent highest risk
- Use tracer data to establish flow patterns for each of the conditions
- In the case of event, select most appropriate weather pattern, use flow field to initiate dispersion model
New BNL Collaborative, Integrated Basic Science, Technology Development and Application Initiative

**Basic Science**
- New perfluoro carbon tracers
- Advanced understanding of microphysical processes
- New coupled modeling approaches across scales
- Coupling of atmosphere-ocean—river-urban-atmosphere models

**Technology Development**
- Model parameterization
- Develop model coupling across scales
- Model testing and validation
- Validate new PFT sampling and analysis techniques
- New phased array radar techniques to study urban environments

**Applications**
- Urban dispersion studies to support national security
- Improved understanding of urban-atmosphere exchange
- Improved design of wind farms and forecasting of solar power generation
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