Monitoring the urban atmosphere in NYC using vertical profilers and surface stations to inform models and benefit society

Mark Arend

The City College of New York
Optical Remote Sensing Lab

NOAA CREST (NOAA Educational Partnership Program)

Including student material by:

Ivan Valerio (Doppler lidar)
Luis Ortiz (uWRF)
David Melecio-Vazquez (PBL climatology)
Overarching Goal

Explore the usefulness of urban observational networks and models for observing and analyzing heat waves

APPROACH

• Operate ground based surface and unique remote sensing meteorological instrumentation for New York City (our test bed for an Urban/Coastal megacity).
• Ingest data in a continuous and automated fashion

• Pick selected meteorological event
  • (this case a heat wave events during 2010 and 2011)
• Characterize vertical profiles

• Develop regional high resolution Urban/Coastal meso-scale model and compare observations and models
Needs for ground based remote sensing and dynamical models in urban environments

• Vertical wind profilers may be used by emergency management agencies to properly represent transport and dispersion of airborne toxins

• Dynamical models need to be able to account for (predict and ultimately assimilate) the vertical structure of the urban atmosphere (temp., wind, humidity, aerosol loading, etc.)

• Urban/coastal health related impacts are diverse
  **Air quality, heat waves**, coastal flooding, etc.
Example Image of Bad Air Quality Day in NYC
The Perfect Storm for Bad Air Quality During Hot Summer Days

**Meteorological Conditions**
- Upper Level Ridge
- Sinking air masses
- High Pressure
- No Clouds
- Higher temperatures

**Planetary Boundary Layer**
- "Mixed layer" does not mix much (low to ground level)

**Societal Reaction**
- Indoor Air Cooling
- Peak Energy Demands Require More Fossil Fuel Burning
Vertical Profilers and Surface Stations Included in the NYC MetNet Network

a) Hyper spectral radiometer
b) Sodar
c) Radar Wind Proifiler
d) Backscatter aerosol Lidar
e) Building top Met Tower
f) Sodar
Available from NYC MetNet Web site
http://nycmetnet.ccny.cuny.edu
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Heat Wave Event June 8, 9 and 10 of 2011
Central Park Temperatures (degrees F)
Reports [AirNow.gov](http://AirNow.gov): “Air quality on Thursday is expected to be Unhealthy for Sensitive Groups (Code Orange or over 100 on the Air Quality Index) in more than 80 cities including: Baton Rouge, La., Indianapolis, Detroit, Nashville, Tenn., Columbus, Ohio, Philadelphia, Pittsburgh, Newark, N.J., Richmond, Va., and Atlanta.”
June 8-10, the upper level ridge was transiting over the East Coast with heights of 5.88 km over NYC. The ridge was centered over the coast on 9 June and slowly moving off the coast on the 10th.
Air temperature measurements (from NYCMetNet) at 1:15 AM during the June 9, 2011 heat wave. The 240 weather stations demonstrate how some neighborhoods around New York City were as much as 15 degrees warmer than rural areas.
Comparing Dynamical Models to Observations

Upcoming slides are a comparison of NYCMetNet surface stations to:

• Coupled Ocean Atmosphere Meso-scale Prediction System COAMPS (0.33 km grid spacing)

Courtesy Teddy Holt and William Thompson, Naval Research Lab
Special Thanks to Tal Meir, Julie Pullen at Stevens Institute of Technology

and

• NOAA National Center for Environmental Prediction (NCEP)
  North American Model (12 km grid spacing)
Future Doppler lidar deployment will be autonomous and transportable (like a Leosphere or Halo)
Current Doppler lidar deployment is in a mobile laboratory (used as a Student Research Platform for Instrument Development)
Next slides show:
- Comparisons between Lidar profilers and Radiometer
- Comparison to uWRF model (RWP)

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Instability near the surface (up to 200 m) is consistent with vertical velocity lifting (see David Melecio-Vazquez talk later).

- This is consistent with the significant aerosol event and the formation of another (lower) cloud layer at 1400 m (next slide)
Coherent Doppler Lidar as compared to Direct Detection Lidar

Level-1 Product: Range-Corrected Elastic-Scattering Return at 532nm
20141031 CCNY-lidar total attenuated backscatter (km^{-3}sr^{-1}) at 532-nm

Level-1 Product: Range-Corrected Elastic-Scattering Return at 1064nm
20141031 CCNY-lidar total attenuated backscatter (km^{-3}sr^{-1}) at 1064-nm

Signal intensity peaks measured at CCNY ON: 10/31/2014

Vertical wind velocity estimated using Matlab MLE 10/31/2014
Comparing June 6, 2011 Radar Wind Profiler to uWRF at LSC
Vertical profilers are used to characterize coastal/urban boundary layer dynamics, to test urban surface parameterization schemes and to offer distributed observations to assist the representation of point measurements.

Outcome:

Summer heat event high resolution models agree reasonably well with observations and might be useful for health related impact studies (e.g. statistical down scaling)

Further investigation is needed to appropriately resolve differences between observations and models 
(must better understand sampling strategies and representativeness)

– Micro scale circulations apparent in the observations
– Sea Breeze effects are complex due to complicated geography
– Sampling times / averaging
– Always room to improve the physics of models and signal processing of obs