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

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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





Stable Boundary Layer

Midnight

Structure of Planetary Boundary Layer

adapted from Stull, 1988.

Surface Layer

Sunset

100 n

Surface Layer

Sunrise

Noon

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 Lidare) Building top Met Towerf) 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)



Air Quality Forecast June 8 2011



Reports <u>AirNow.gov</u>: "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."

SYNOPTIC PATTERNS THURSDAY JUNE 9, 2011

<u>June 8-10</u>, 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 fo Environmental Prediction (NCEP) North American Model (12 km grid spacing)

June.8 EST

10 meter air temperatures



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)





- a) Hyper spectral radiometer
- b) Sodar
- c) Radar Wind Proifiler

d) Backscatter aerosol Lidare) Building top Met Towerf) Sodar

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 1064nm

20141031 CCNY-lidar total attenuated backscatter (km⁻¹sr⁻¹) at 1064-pmp-³







Comparing June 6, 2011 Radar Wind Profiler to uWRF at LSC



Conclusion

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