Applying Joint Urban Testbed Results to the Meteorological Needs of the Army

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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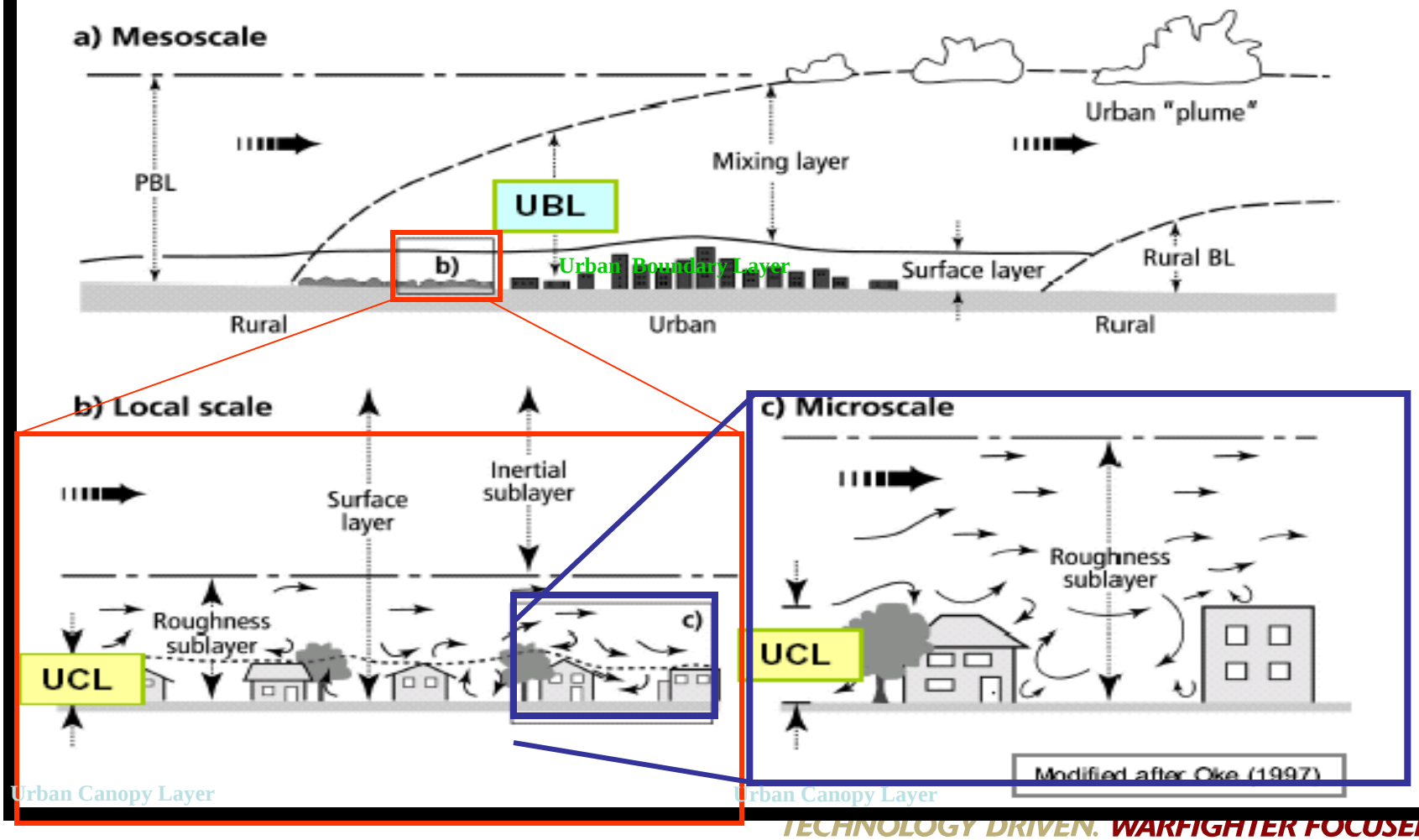
10-12 July, 2007

Urban Testbeds and Army Weather Needs Preview

- **Background**
- **Urban Warfare Concerns--Needs are Similar for Homeland Defense at CONUS Testing and Training Ranges**
  - **Transport and Diffusion of Toxic Agents and Obscurants, Soldier Health and Safety**
  - **Optical and Acoustic Sensor Performance--Propagation at Short Ranges in Cluttered Backgrounds**
  - **UAV Operations around Obstructions and through Turbulence**
- **New Sensor Test and Evaluation**
- **Networking of Sensor Data/Fusion of Data with Urban Models/Integration with GIS Databases**
- **Communication of Total Picture through Mobile Nodes to Decision Makers**

Urban Testbeds and Army Weather Needs

Scales and Layers Relevant to Urban Climate



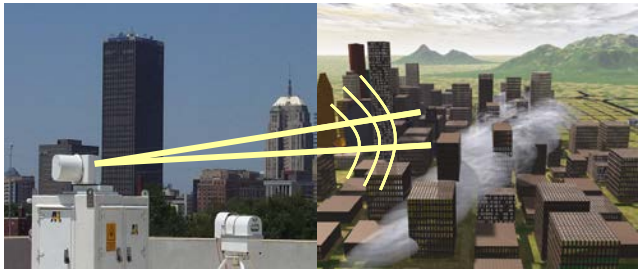
Urban Warfare Concerns

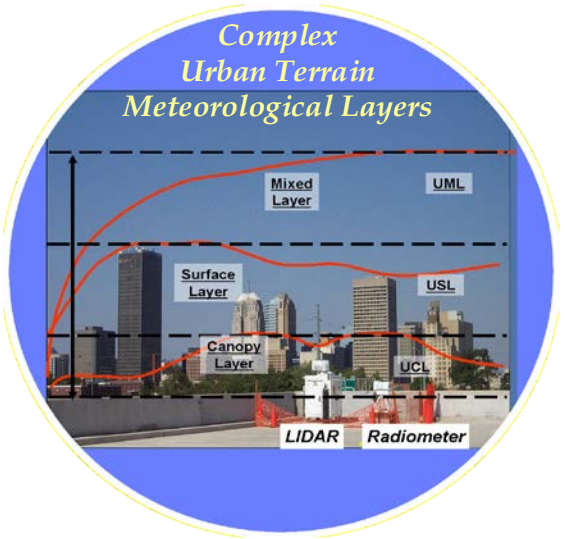
Transport and Diffusion of Toxic Agents and Obscurants, Soldier Health and Safety

Urban Testbeds Support Needed Atmospheric Boundary Layer Research

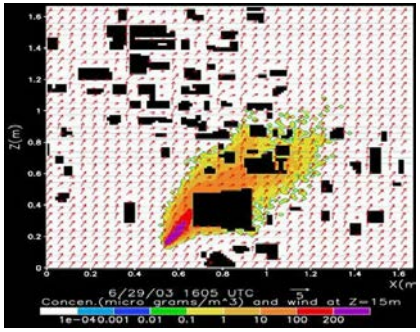
- **Design and execution of field experiments to characterize boundary layers in all stability regimes for more accurate CBRN hazard prediction.**
- **Tower data for "few building" wind flow have been collected and will be used to evaluate ARL 3DWF and LANL QUIC-URB micro-met urban models with measured data.**
- **With DTRA support, ARL CISD & ARO have initiated a research program to address the lack of science in stable atmospheric boundary layer dynamics for CBRN hazard prediction.**

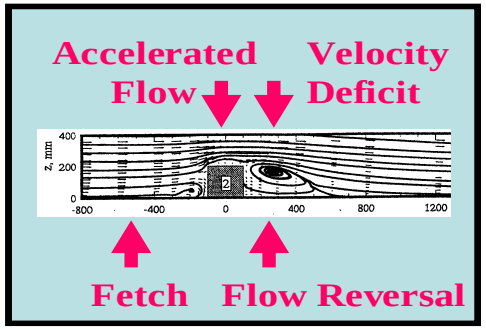
Doppler wind LIDAR





Urban model



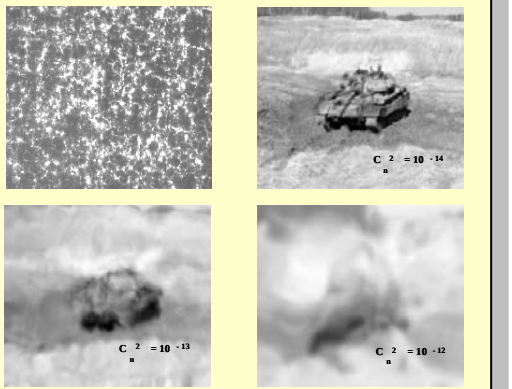


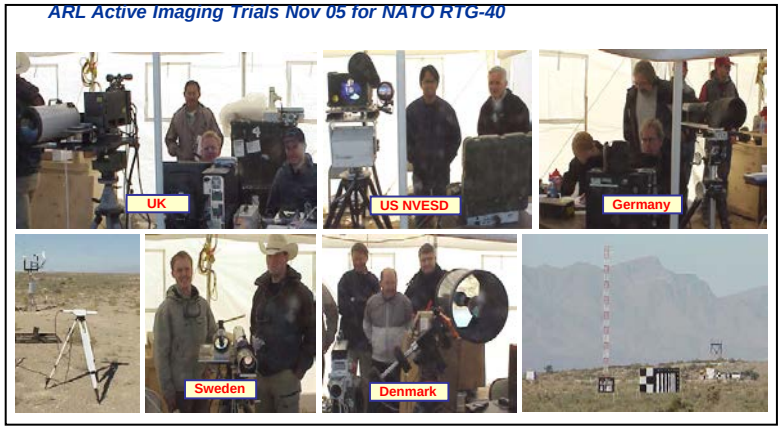
Urban Warfare Concerns

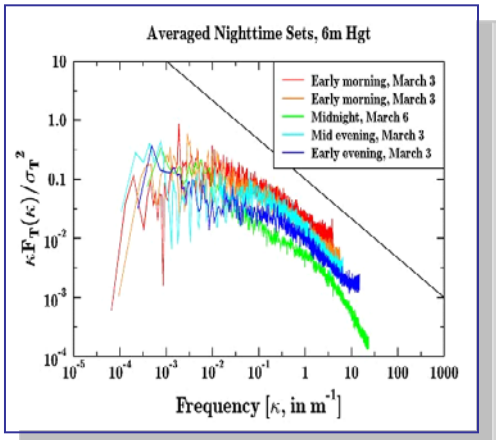
Optical and Acoustic Sensor Performance
Propagation at Short Ranges in Cluttered Backgrounds

Urban Testbeds Support Needed Atmospheric Electro-Optical and Acoustic Propagation Research

- **Current atmospheric models do not treat the wave band or propagation effects on next generation Army EO sensors. Acoustic detection in urban domains is complicated by clutter and noise.**
- **Specialized EO propagation environment measurements to verify effects and models for next generation THz band imagers and for emerging long range stand-off sensors combining active coherent illumination and incoherent imaging of targets**
- **An initial NATO RTG-40 field trial of next generation coherent active illumination and passive incoherent imaging of targets was led by ARL CISD/BE at WSMR in Nov 2005. Measurements of atmospheric water vapor fluctuations that limit THz passive imaging was also begun in FY05 and continues.**



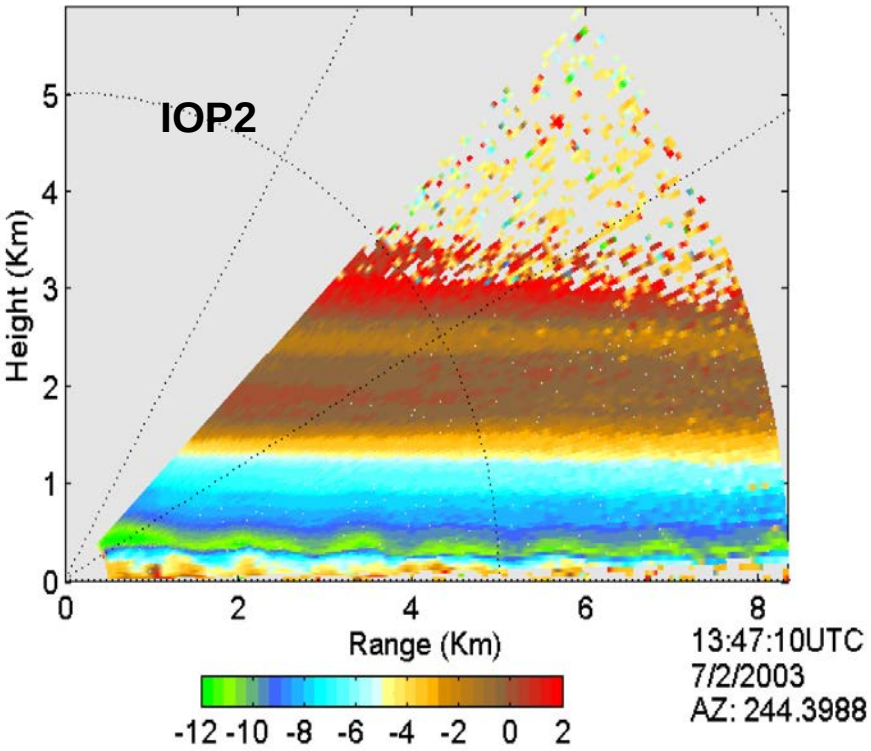


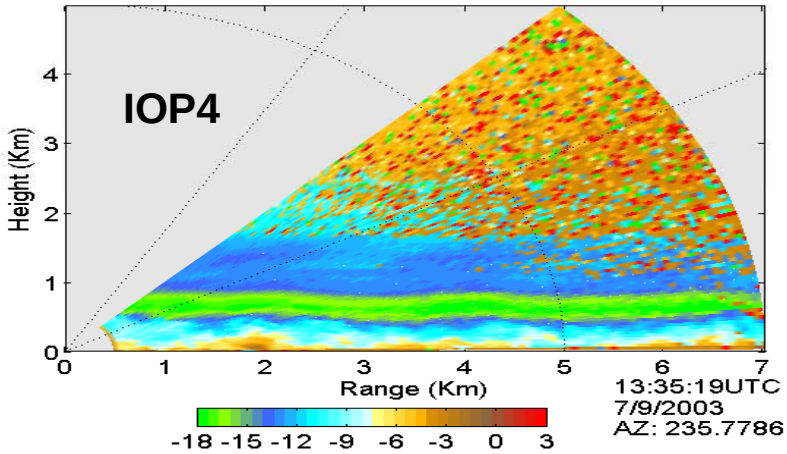


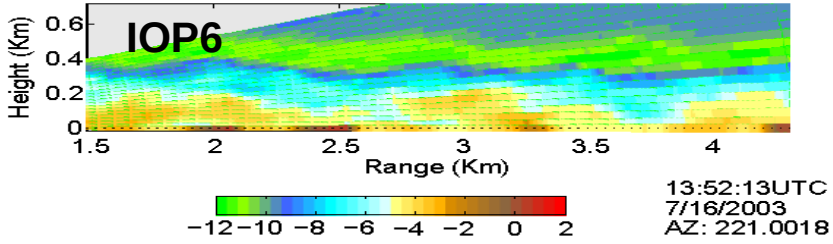
Urban Warfare Concerns

UAV Operations around Obstructions and through Turbulence

Urban Test-beds Support Needed Research to Ascertain Turbulence Levels Potentially Hazardous to UAV Operations Close to the Ground.

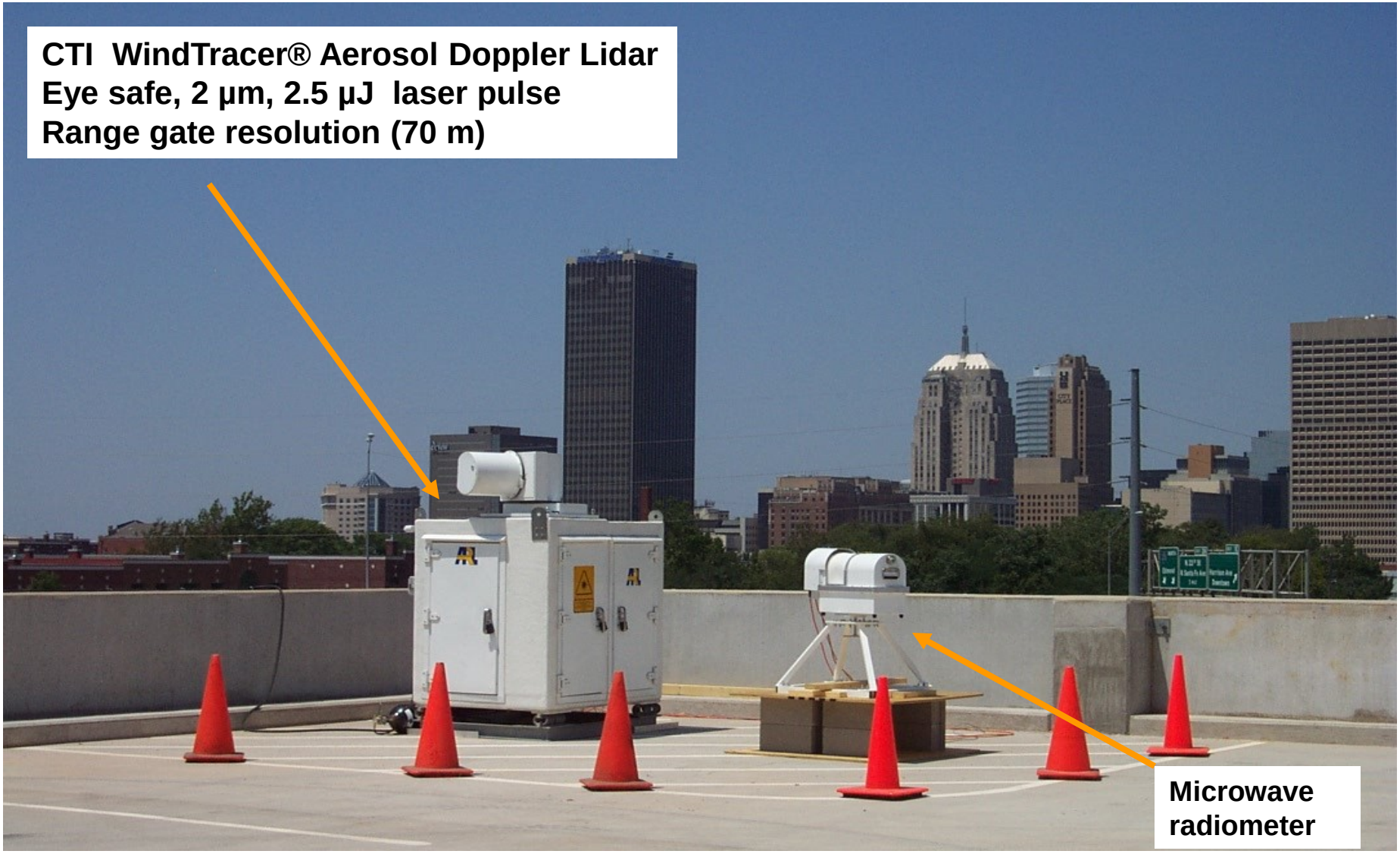






Gravity waves and turbulence due to the strong shear and stratification of the low-level jet. (Wang)

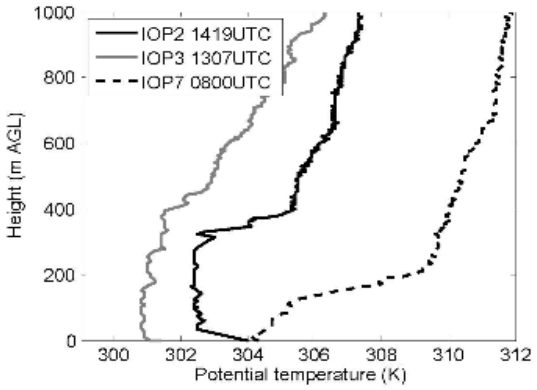
New Sensor Test and Evaluation



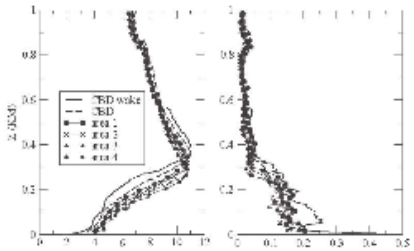
ProNew Sensor Test and Evaluation

Analysis of lowest kilometer of the urban atmosphere during 3 IOPs (Wang et al, 2005)

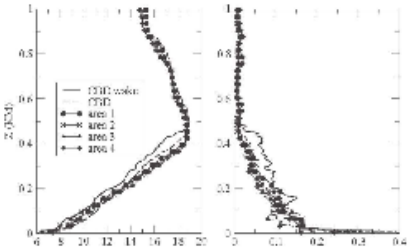
Note change in boundary layer height from daytime IOPs 2 & 3 (300 to 400m) to nighttime IOP 7 (~200m).



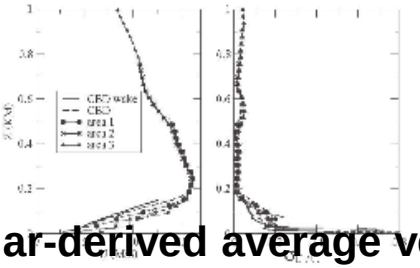
Mean potential temperature profiles observed from radiosonde operated by Pacific Northwest National Laboratory. Sunrise is approximately at 1130 UTC.



IOP2



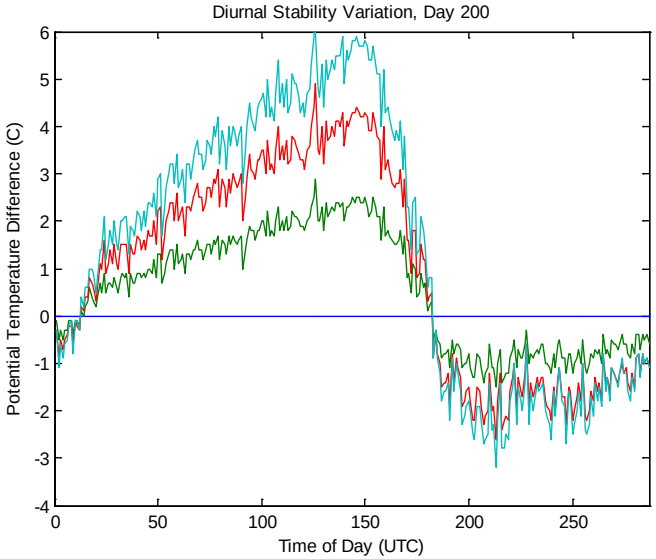
IOP3

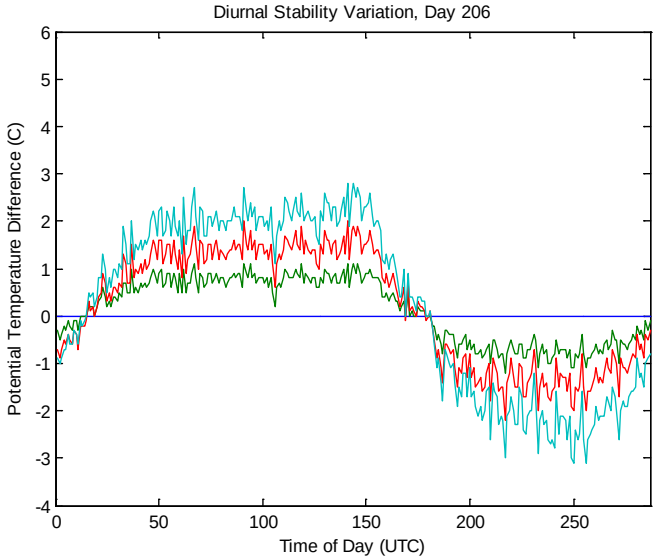


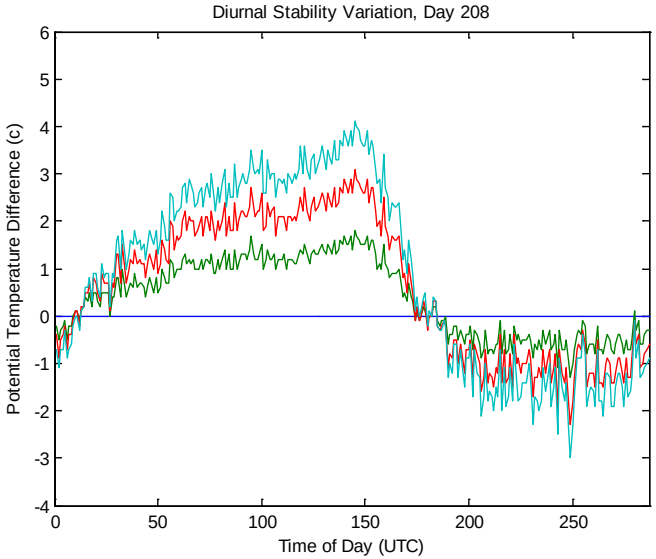
IOP7

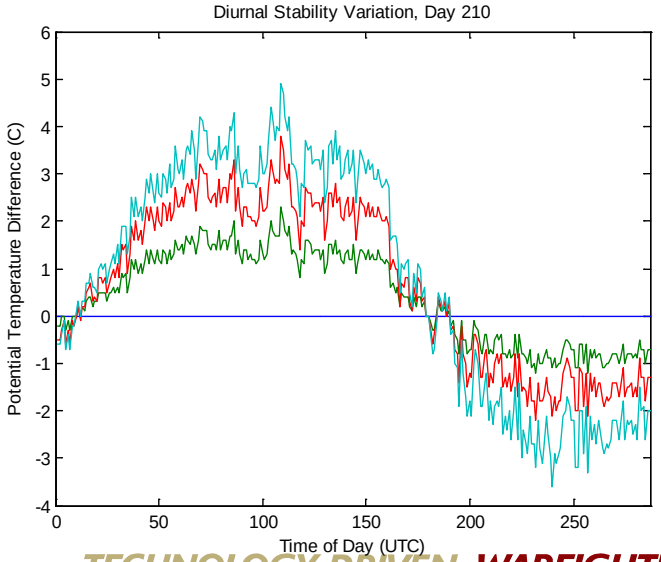
Doppler lidar-derived average vertical profiles of U and normalized standard deviation according to the underlying morphological characteristics.

New Sensor Test and Evaluation







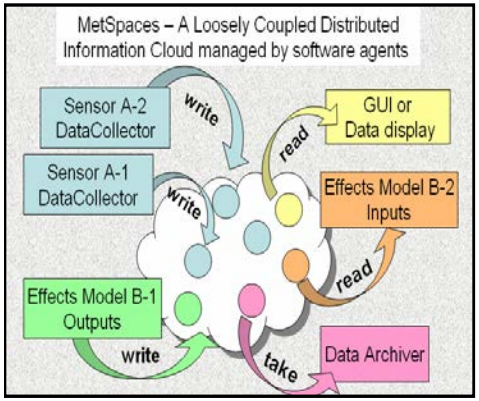


Battlefield Weather Data and Fusion

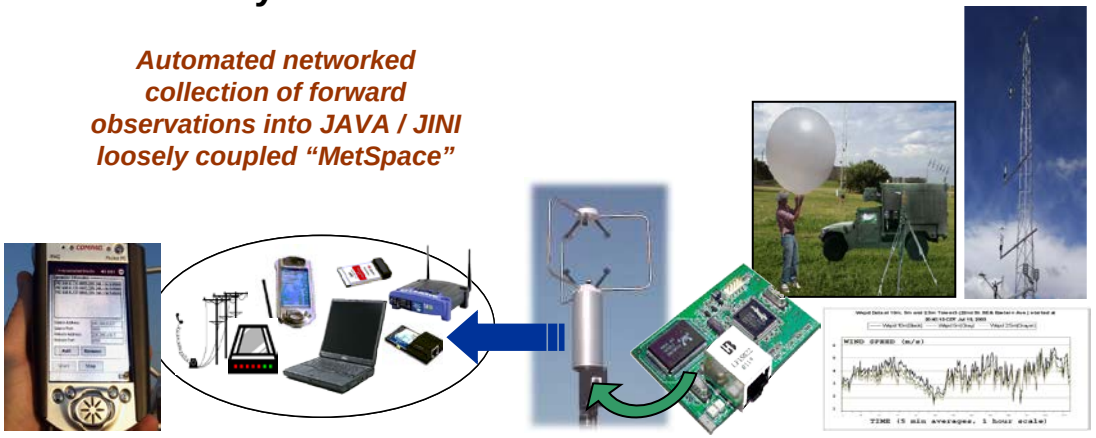
Battlefield Weather Data and Fusion R&D Focus

(Driven by DCGS-A and FCS Situational Understanding (SU) Weather Requirements)

- **The Army has little experience with automated collection of forward area weather data and its fusion with high fidelity boundary layer met models to provide actionable intelligence.**
- **BED/CISD is prototyping automated data collection and networking technologies using remote sensing capabilities together with conventional and non-conventional meteorological data sources.**
- **The networked sensor data is fused with high fidelity, fine scale numerical models over complex terrain and urban domains both to evaluate the model outputs and to provide situational awareness on the battlefield.**
- **The total system is not unlike that needed to provide emergency management personnel the information necessary for homeland defense scenarios.**



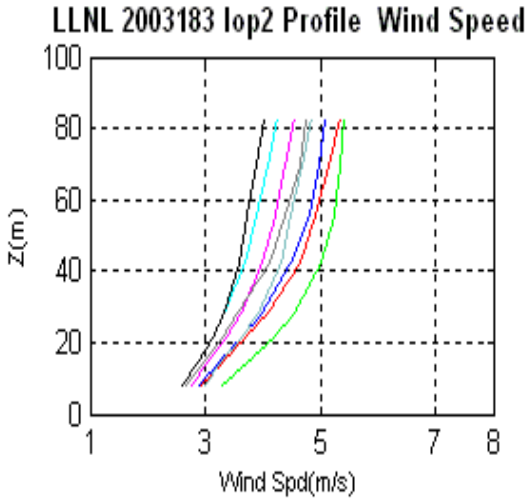
Automated networked collection of forward observations into JAVA / JINI loosely coupled "MetSpace"

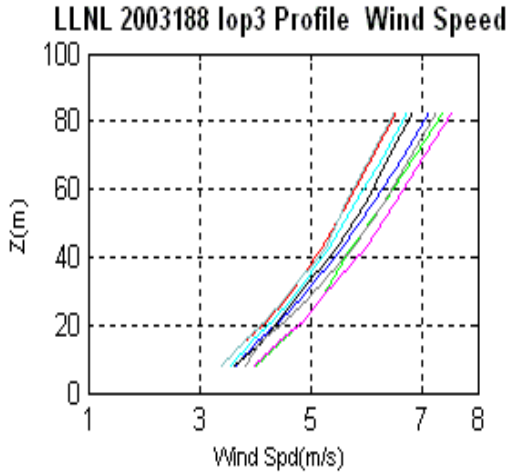


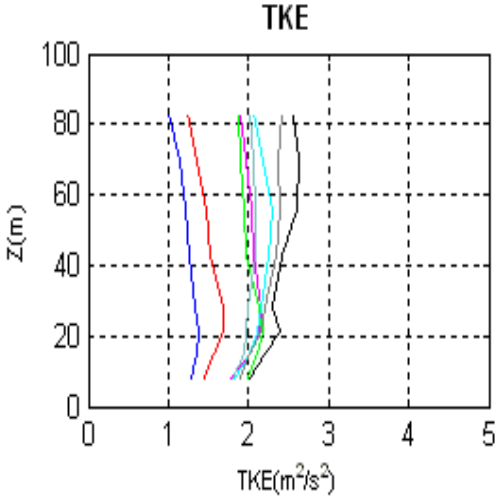
Battlefield Weather Data and Fusion

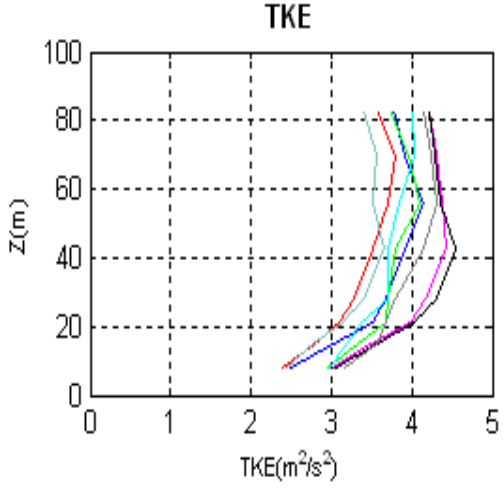
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Profiles of Wind Speed and TKE in an Urban Boundary Layer









Daytime Profiles of Wind Speed and TKE

Daytime IOPs 2 and 3

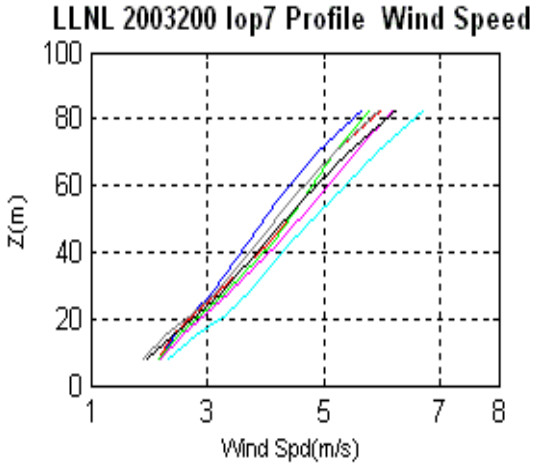
Both wind speed and TKE profiles are significantly different.

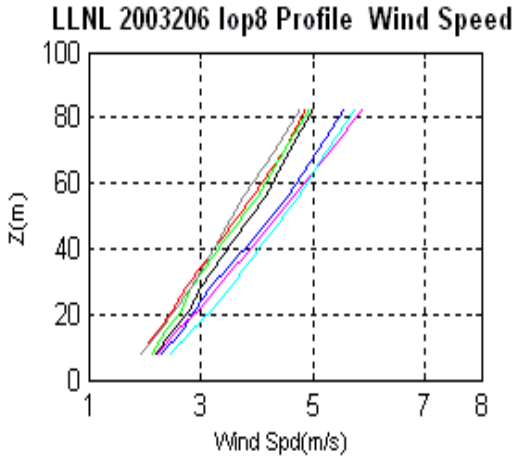
IOP2: Lighter winds approaching ~5m/s at top of tower; slight increase in TKE to 20m, relatively constant above, increase with time at all levels during the first two hours.

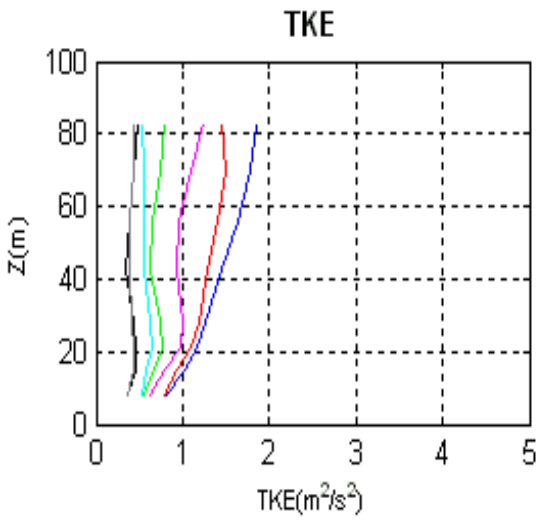
IOP3: Stronger winds in excess of 7m/s at top of tower and continued increase with height above; sharp increase in TKE to 20m and continued increase above up to 40 or 70m, slight decrease above.

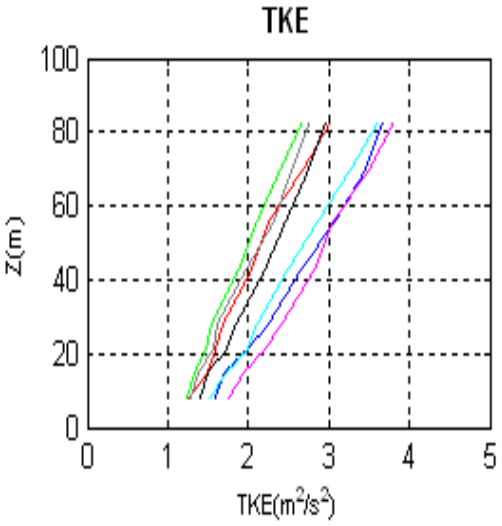
Data suggest a source of TKE at about 20m during IOP2 and a more elevated source at 40m or above during IOP3.

Profiles of Wind Speed and TKE in an Urban Boundary Layer









Nighttime Profiles of Wind Speed and TKE

Nighttime IOPs 7 and 8

Wind speed profiles similar, TKE profiles significantly different.

IOP7: TKE nearly constant or slightly increasing with height, varying from about 0.5 to almost 2 m^2/s^2 at top of tower; increase with time at all levels during first two hours..

IOP 8: TKE increases upwards at all levels at all times, attaining levels in excess of 3 m^2/s^2 at top of tower.

Potential source levels of TKE hard to identify from data.

Urban Testbeds and Army Weather Needs Summary

Summary

Both current and potential future Army operations often must be conducted in urban domains. The Army's principal weather concerns for urban warfare have been outlined here and might be summed up as an adequate knowledge of the wind and turbulence fields in the urban boundary layer (UBL).

The complexity of the lowest sub-layers (RSL and CFL) and the heterogeneity of the UBL make it necessary to utilize fine-scale models to describe its state and dynamical structure. Although the underlying terrain and morphology data (GIS) needed for the lower boundary conditions is generally becoming available, the met data adequate to fuse with or initialize such models is seldom present.

Urban test beds will serve as platforms to test and evaluate sensors necessary to characterize the atmospheric conditions at small scales as well as Army sensor systems (electro-optical and acoustic) needed for target recognition and toxic agent detection.

The fusion of such data with fast-running fine-scale models will enable us to evaluate the uncertainty in the model outputs and estimate optimum sensor densities and sitings.

The final networked urban testbed system should be capable of providing emergency managers the information required for rapid response decisions and extrapolated to urban environments for which a testbed has not existed, thus providing commanders and soldiers on the battlefield the situational awareness necessary to survive and win.

Oklahoma City JU2003 (Wang)