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Urban Warfare:
Detailing Single Building
Airflow, Turbulence and Stability Variation
Characteristics

**Gail-Tirrell Vaucher,
Ronald Cionco, Manuel Bustillos,
Sean D'Arcy, Robert Dumais, SFC Robert Brice
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White Sands Missile Range, NM 88002**



OUTLINE



1. BACKGROUND

- Military Interest in Urban Atmosphere.**
- Urban Atmosphere: Thermodynamic/Dynamic Patterns.**
- Simplifying the Urban Study.**

2. WSMR Urban Study – General Information.

3. 2003 March: Phase I Results Reviewed.

4. 2005 March: Phase II Preliminary Results.



1. BACKGROUND

Military Interest in Urban Atmospheric.

- CALL Newsletter No. 99-16, Chapter 9 (*Flight Operations in Urban Areas*); Observation 16 (Environmental Considerations).

•Winds

- Broken up winds, funneled down street/alley.
- Turbulence in canyons impact aircraft performance & weapon delivery.

•Temperatures

- Thermal heating affected by buildings (can be 10-20C warmer than rural).
- Adversely affect thermal sights on aircraft.

•Visibility

- Smog reduces visibility, increases target acquisition/threat exposure time.
- Weapon sensors degraded; laser guided weapons “severely affected”.

- Aviation Urban Operations Manual –Joint Air, Land, Sea Applications Center

• Wind Patterns: Mission Planning Factors.

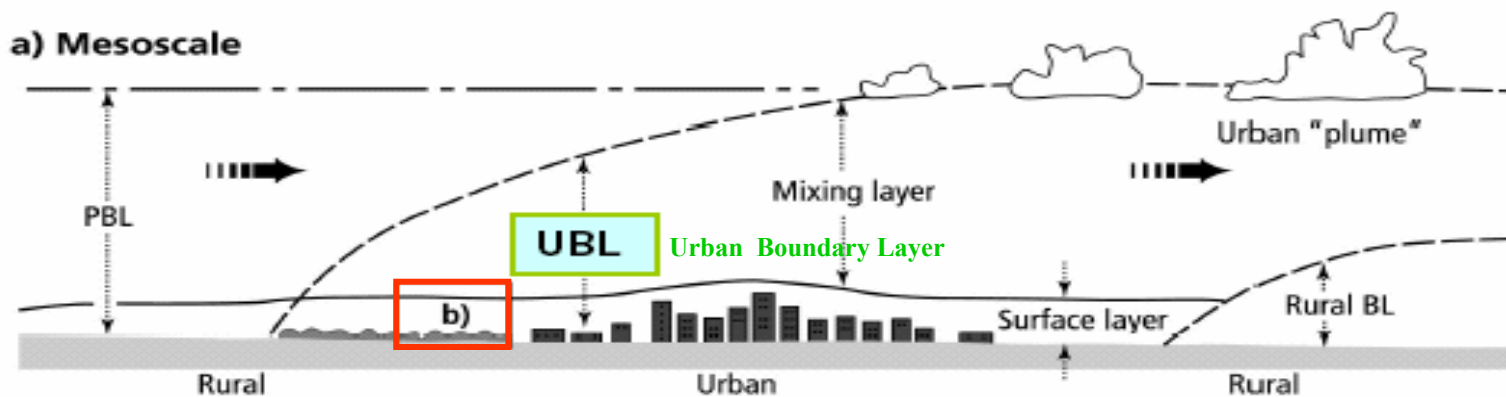
- Degraded Night Vision Systems. [UHI effect also].
- Degraded communications.
- Degraded Visibility and Toxic Fumes.



1. BACKGROUND

Urban Atmosphere

Scales and Layers Relevant to Urban Climate



Ability to simulate the urban atmosphere is dependent upon understanding urban

- dynamic airflow behavior and
- thermodynamic properties,

above and about buildings and their surroundings.

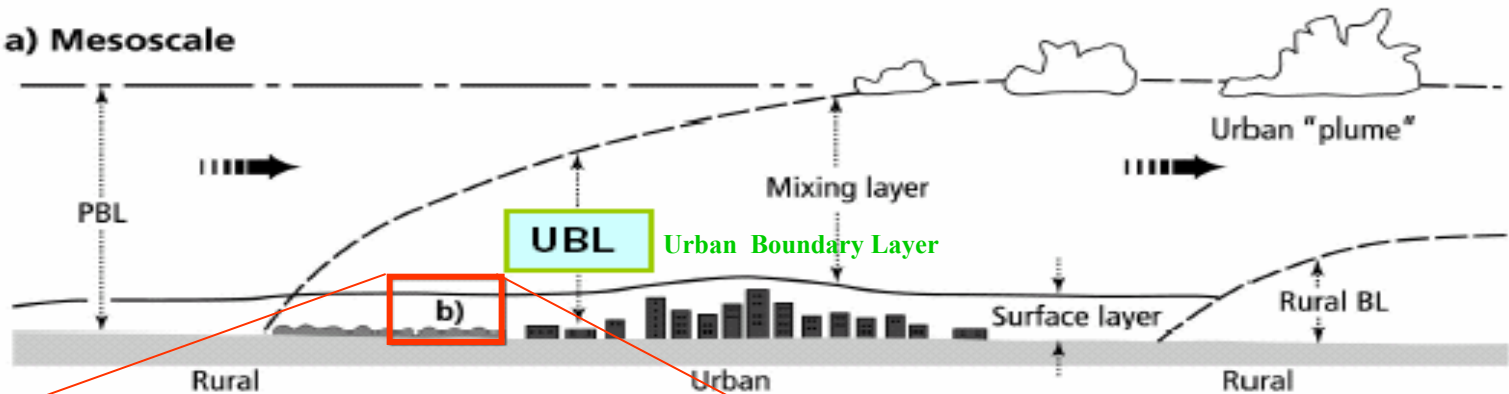


1. BACKGROUND

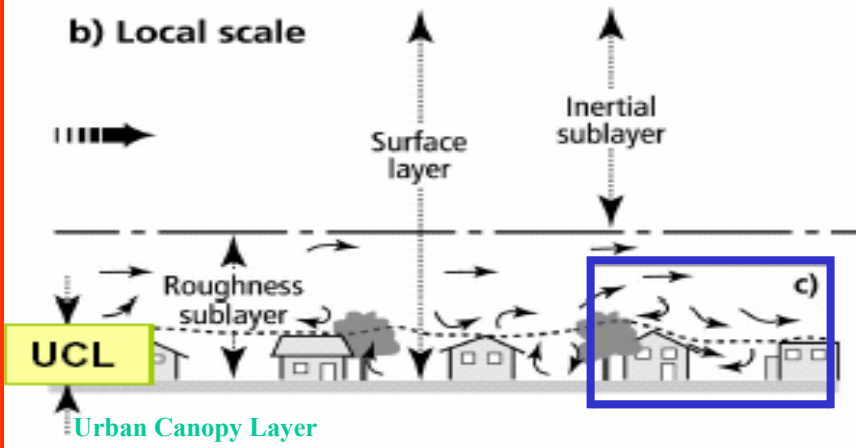
Urban Atmosphere

Scales and Layers Relevant to Urban Climate

a) Mesoscale



b) Local scale

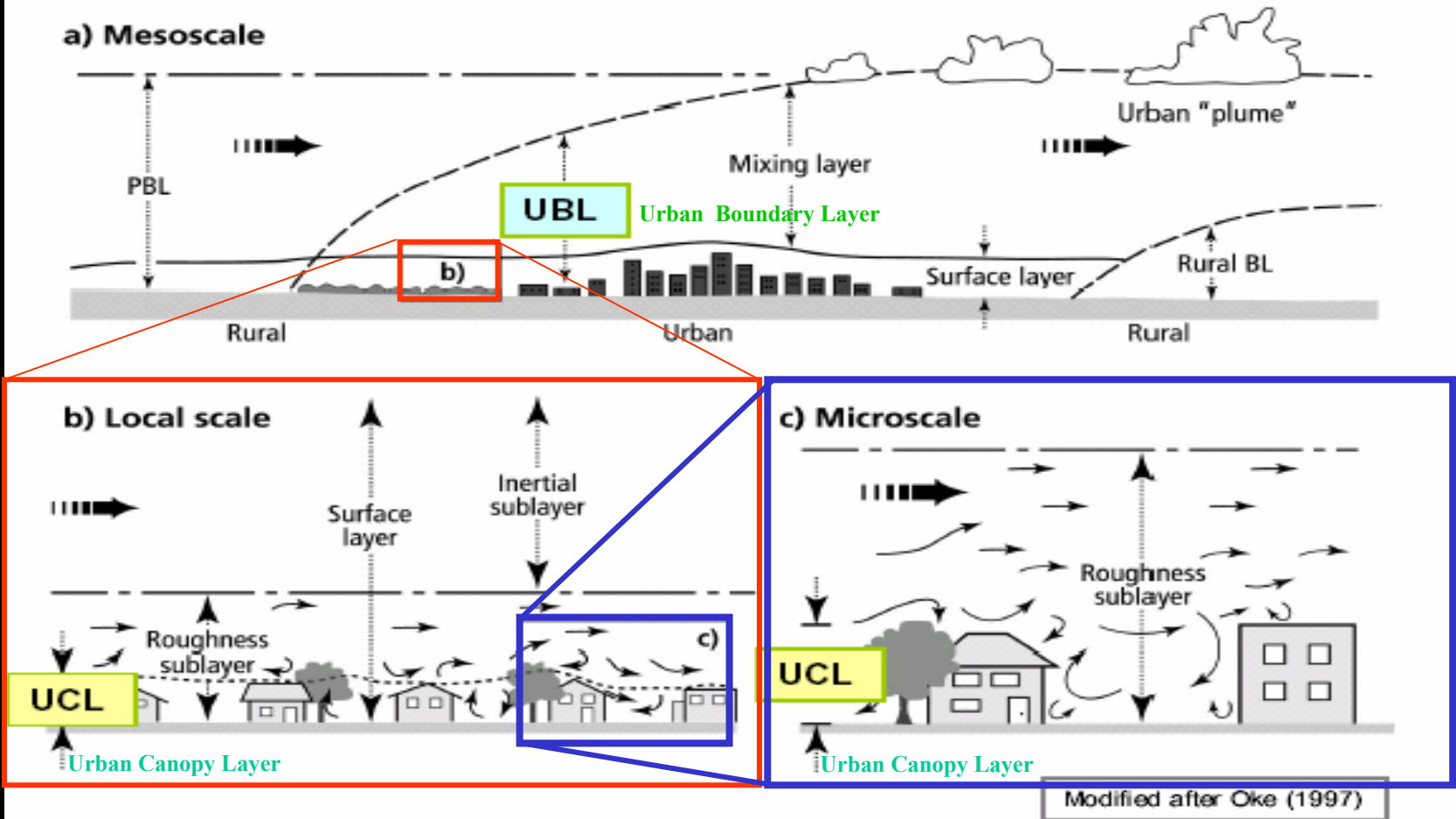




1. BACKGROUND

Urban Atmosphere

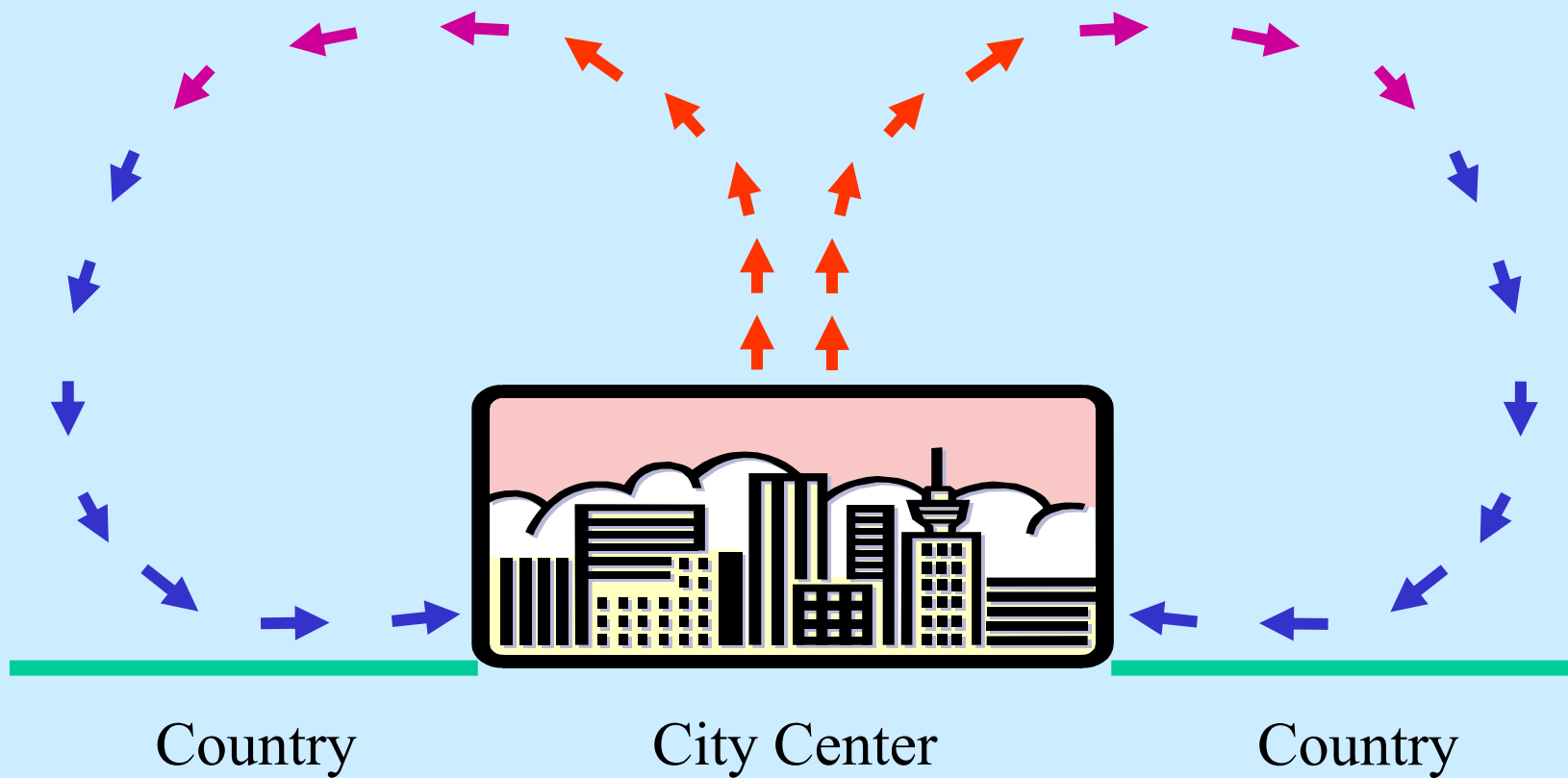
Scales and Layers Relevant to Urban Climate





1. BACKGROUND

Urban: Thermodynamic Patterns.



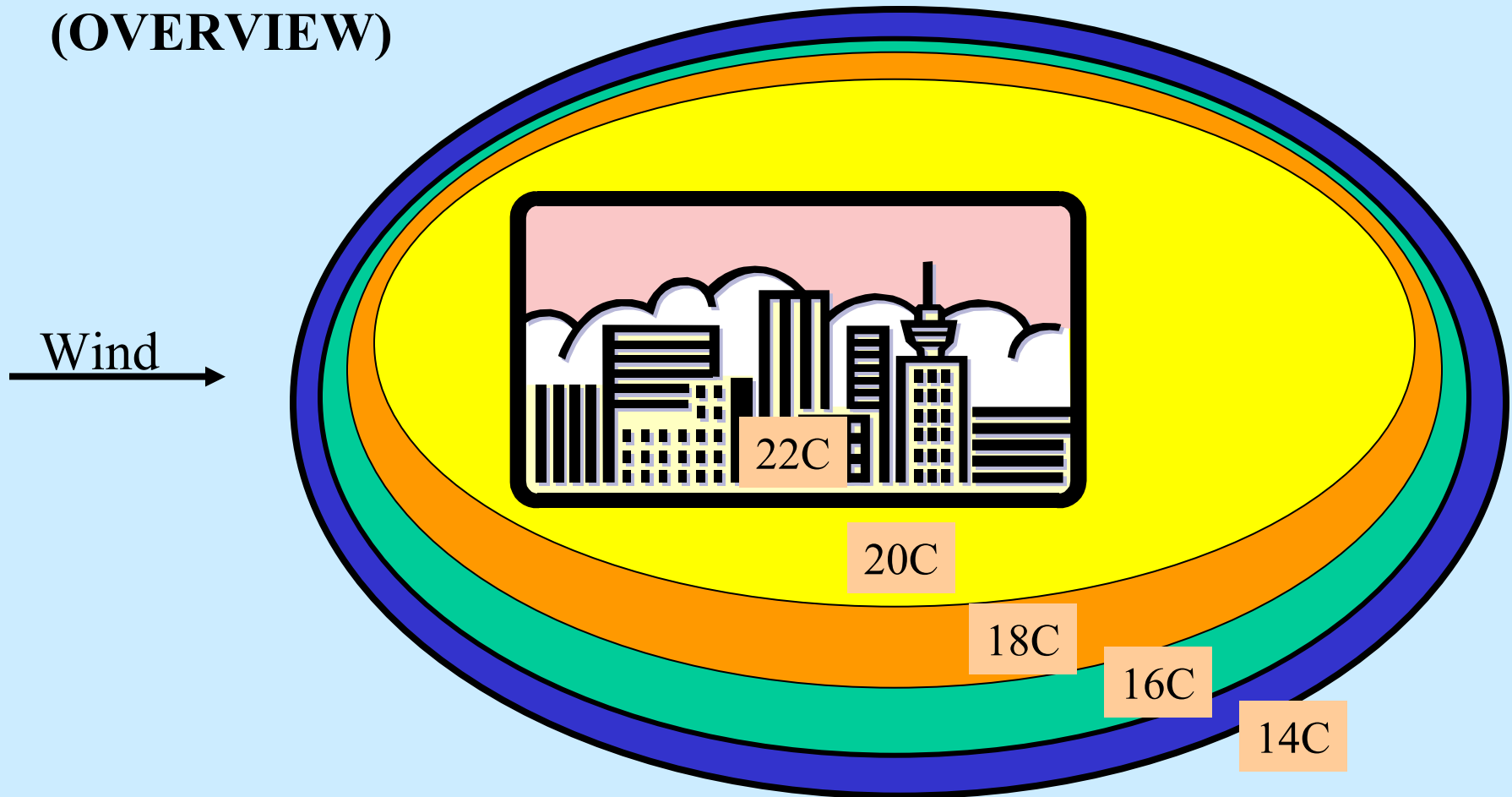


1. BACKGROUND

Urban: Thermodynamic Patterns.



(OVERVIEW)



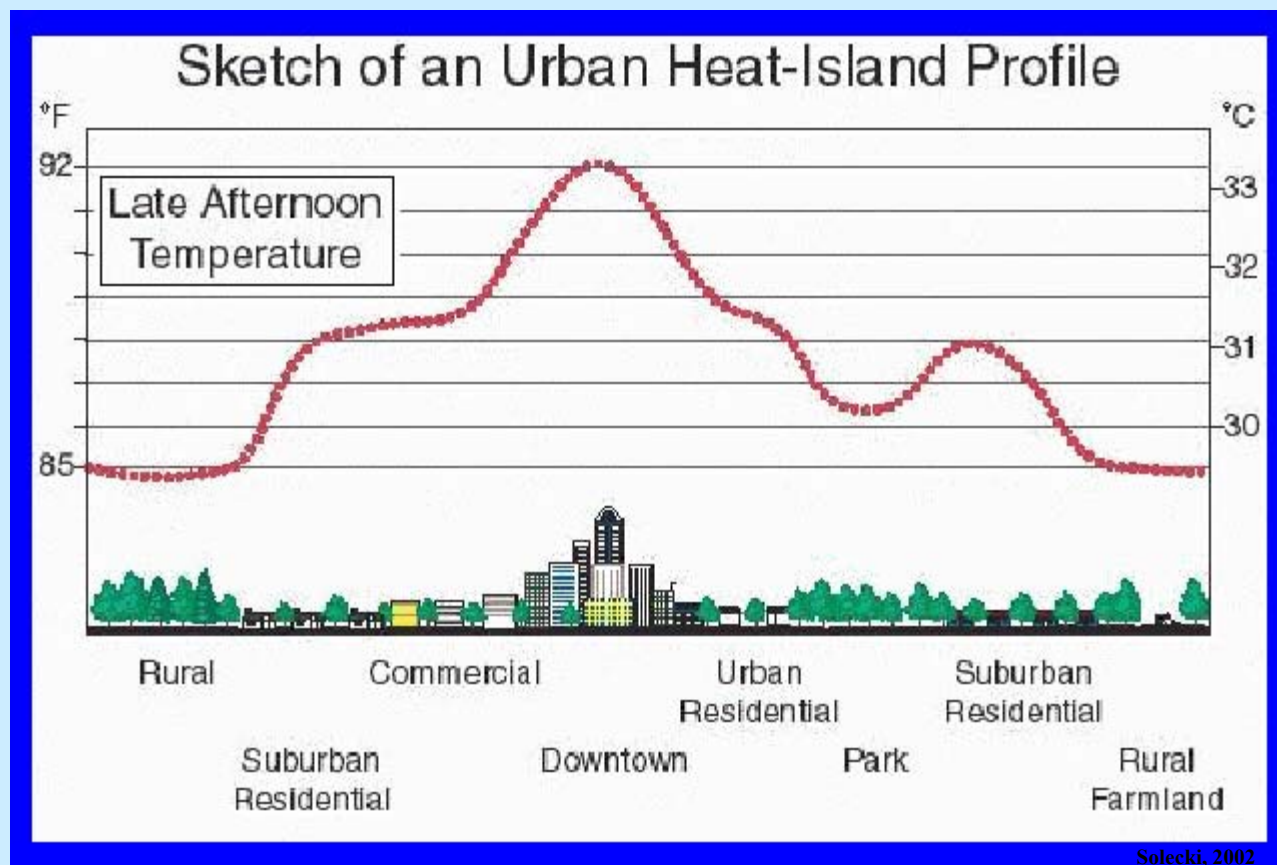
Luke Howard – First to discover Urban Heat Island [UHI].
Gordon Manley (1958) - First English Pub with UHI



1. BACKGROUND

Urban: Thermodynamic Patterns.

Vertical
cross-
section

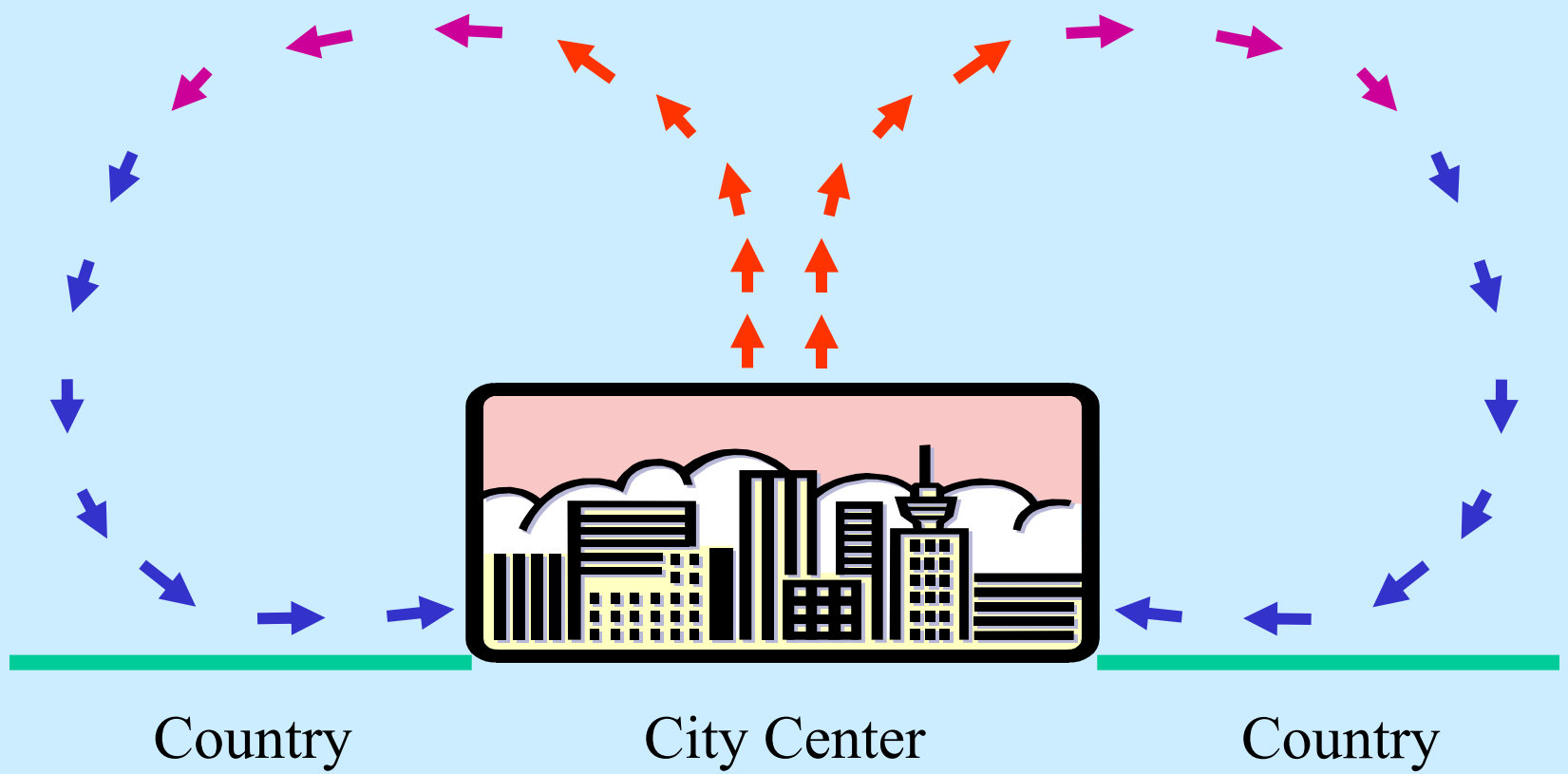


U.S. Dept of Energy:
“On warm summer days, the air in a city can be 6-8°F hotter than the surrounding countryside.”



1. BACKGROUND

Urban: Thermodynamic/Dynamic Patterns.





1. BACKGROUND: Dynamic Patterns. Channeling/Canyon Flow/Complex Flow



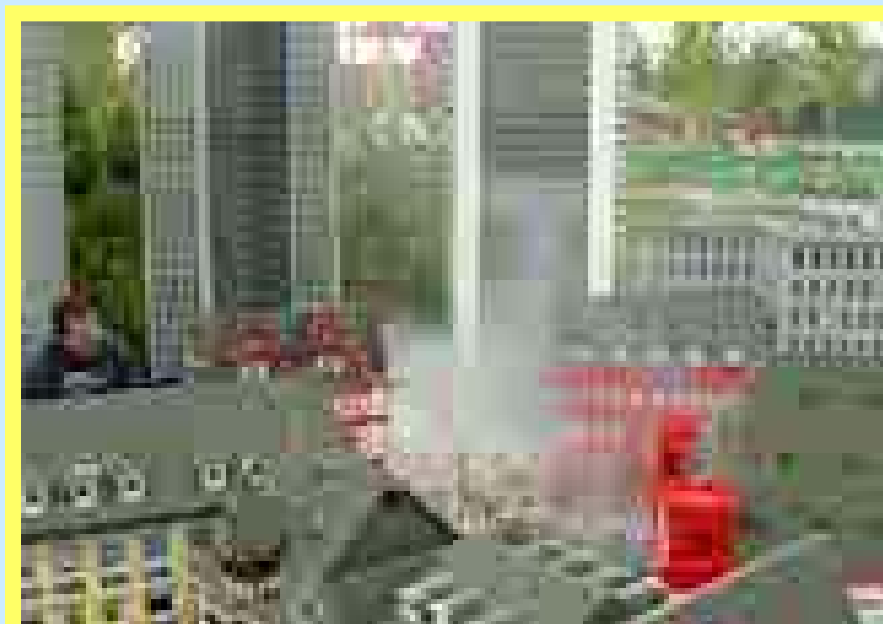
side view



1. BACKGROUND: Dynamic Patterns. Complex Airflow around Tall Buildings



Complex Airflow around Tall Buildings and...



Short Buildings...



1. BACKGROUND: Dynamic Patterns. Simplifying the Urban Study

Reduce problem to two options:

1. Multiple buildings (city downtown areas) and
2. Single buildings (large store/factory/office bldg and parking lot).





2. WSMR Urban Study

Air Flow and Stability Variations Around a Single Building

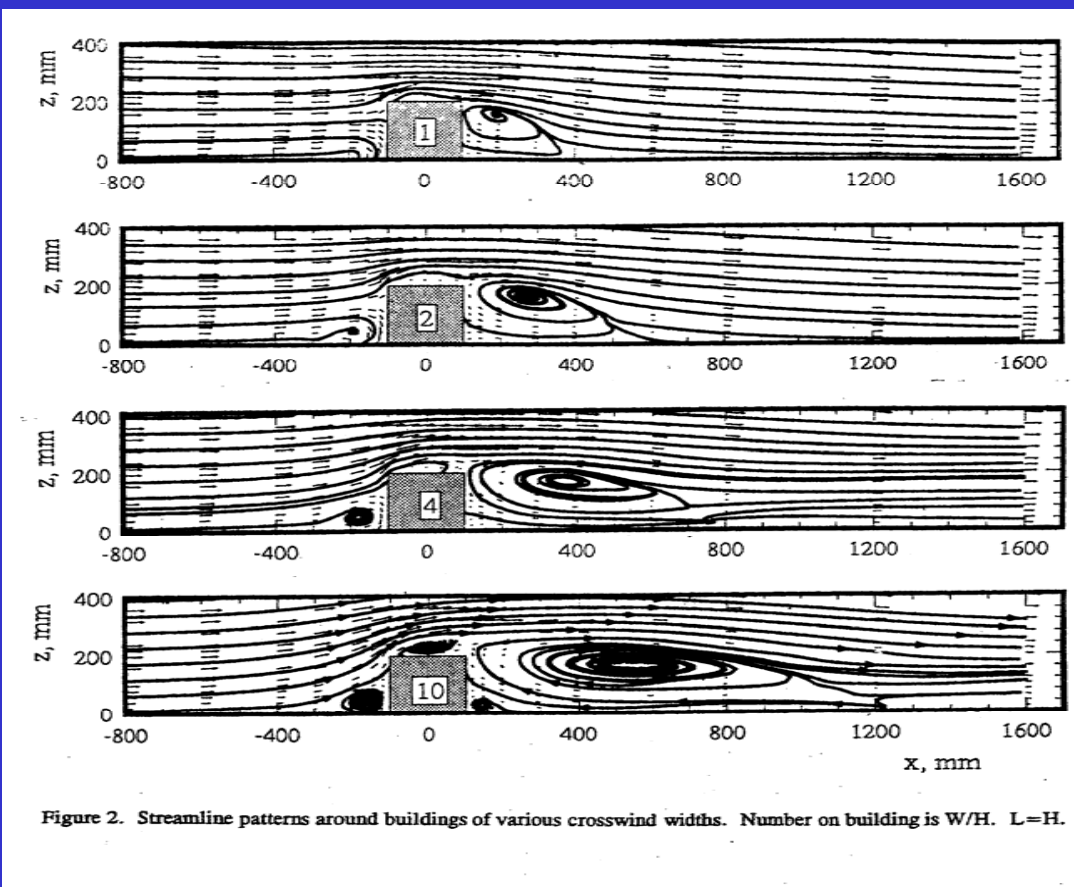


- **2003 March Field Test – Mean Flow/Stability.**
- **2005 March Field Test – Turbulent Conditions.**



2. WSMR Urban Study

Wind Tunnel Flow Fields, Snyder and Lawson, 1994

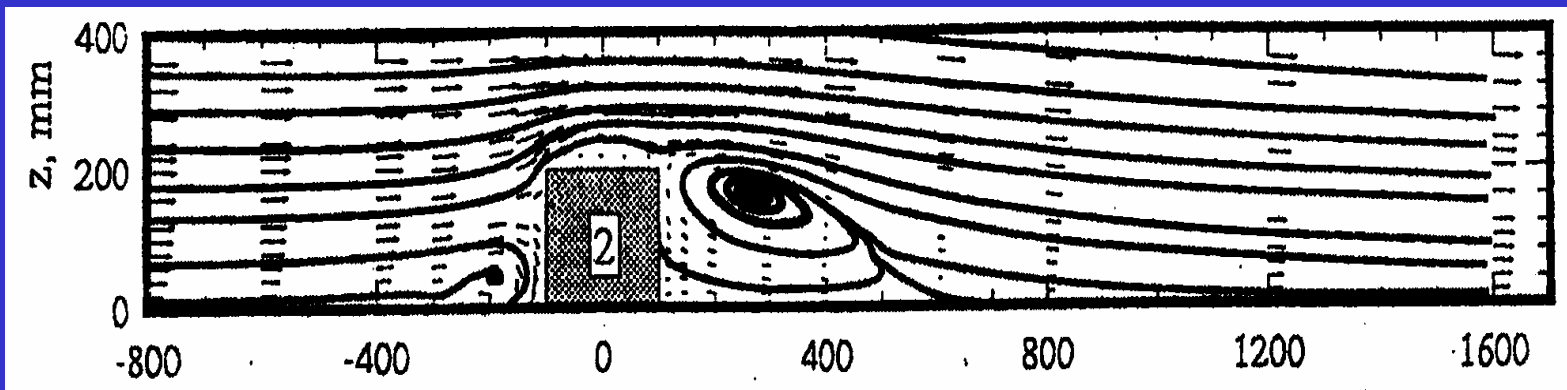




2. WSMR Urban Study

Accelerated Flow

Velocity Deficit

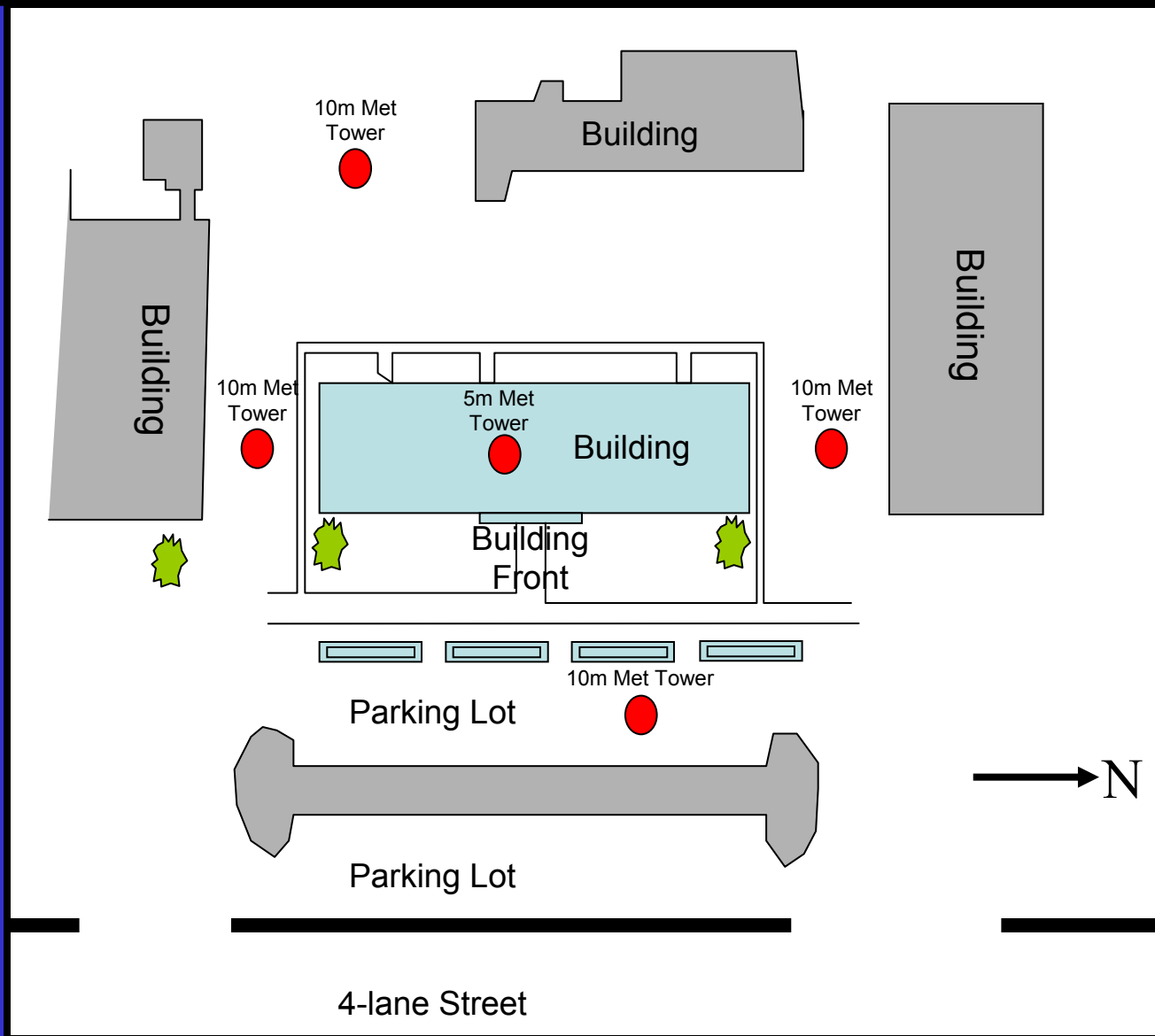


Fetch flow

Flow Reversal



Field Site Layout (Not drawn to scale)





3. 2003 March: Phase I Results Reviewed.

Air Flow

⇒ Results presented in 3 perspectives:

- Numerically (Measurement Sample)
- Graphically (Time series)
- Visually (Photograph)

Strong West Winds Case (JD 86.422)

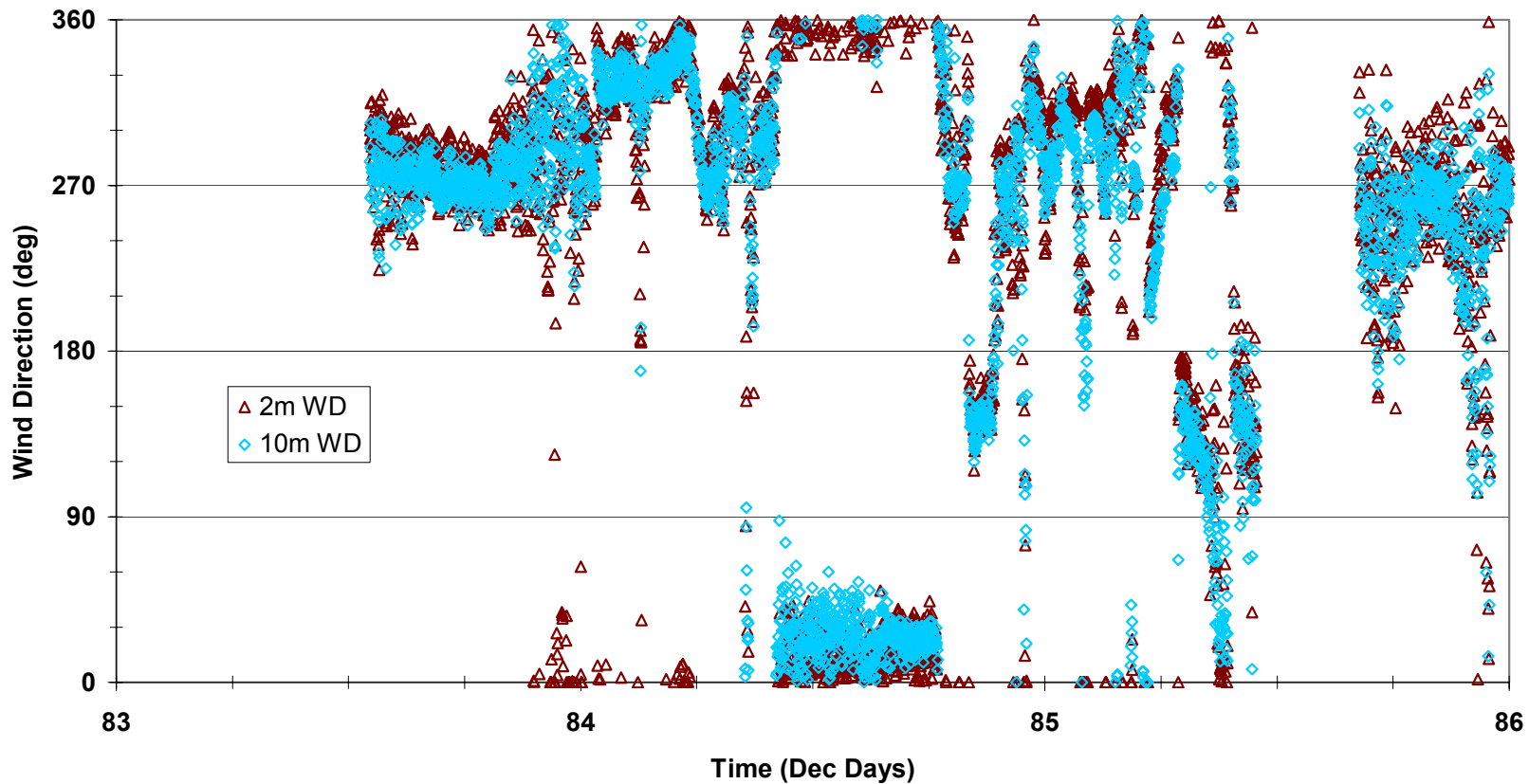
<u>TWR:</u>	<u>SW</u>	<u>ROOF</u>	<u>EAST</u>	<u>NORTH</u>	<u>SOUTH</u>	
10M:	13.64	14.54	W 8.4	14.6	15.4	m/s
2M:	7.1	----	E 2.8	9.22	11.7	m/s



3. 2003 March: Phase I Results Reviewed.

Southwest Tower: UPWIND CONDITIONS

PreTest#1: SouthWest Tower
Julian Dates 83-90 [2003 Mar 24-31]
Wind Direction





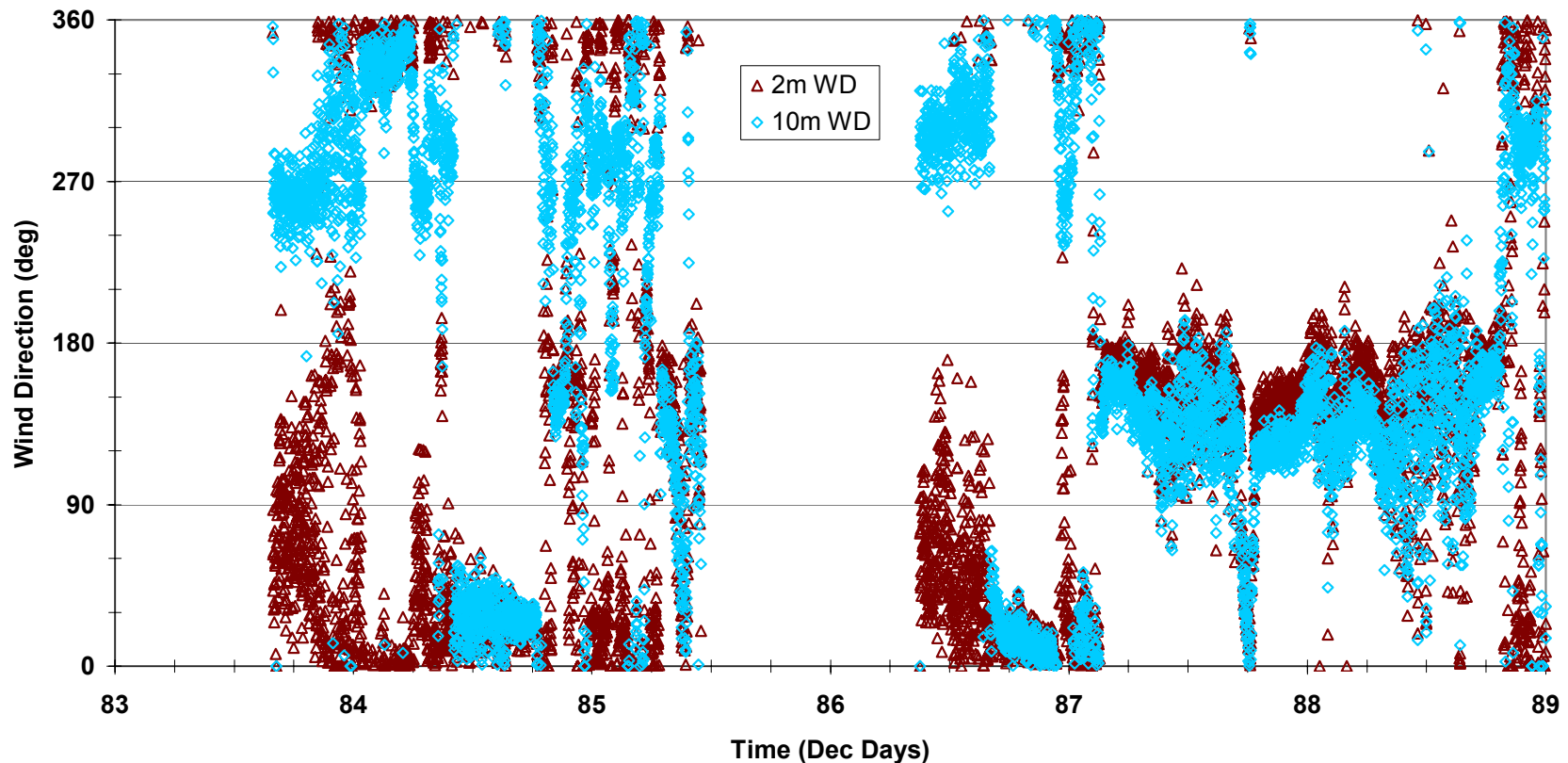
3. 2003 March: Phase I Results Reviewed.

East Tower: DOWNWIND OF BUILDING

PreTest#1: East Tower

Julian Dates 83-90 [2003 Mar 24-31]

Wind Direction



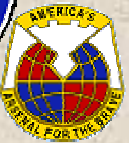


3. 2003 March: Phase I Results Reviewed.



East Tower:
BUILDING LEESIDE
CAVITY ZONE



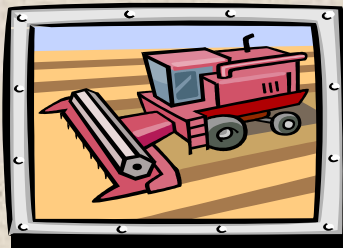


3. 2003 March: Phase I Results Reviewed.

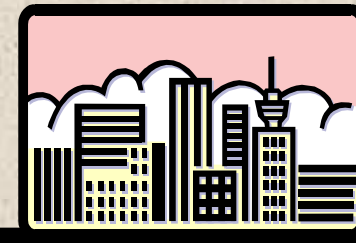


Stability Variations

T_{Rural}



T_{Urban}



Rural Pattern

Day - Unstable

Night – Stable

Transitions = two.

2003 Mar 12

Urban Pattern

Day – Unstable

Night – Unstable/Neutral

Transitions = Intermittent.

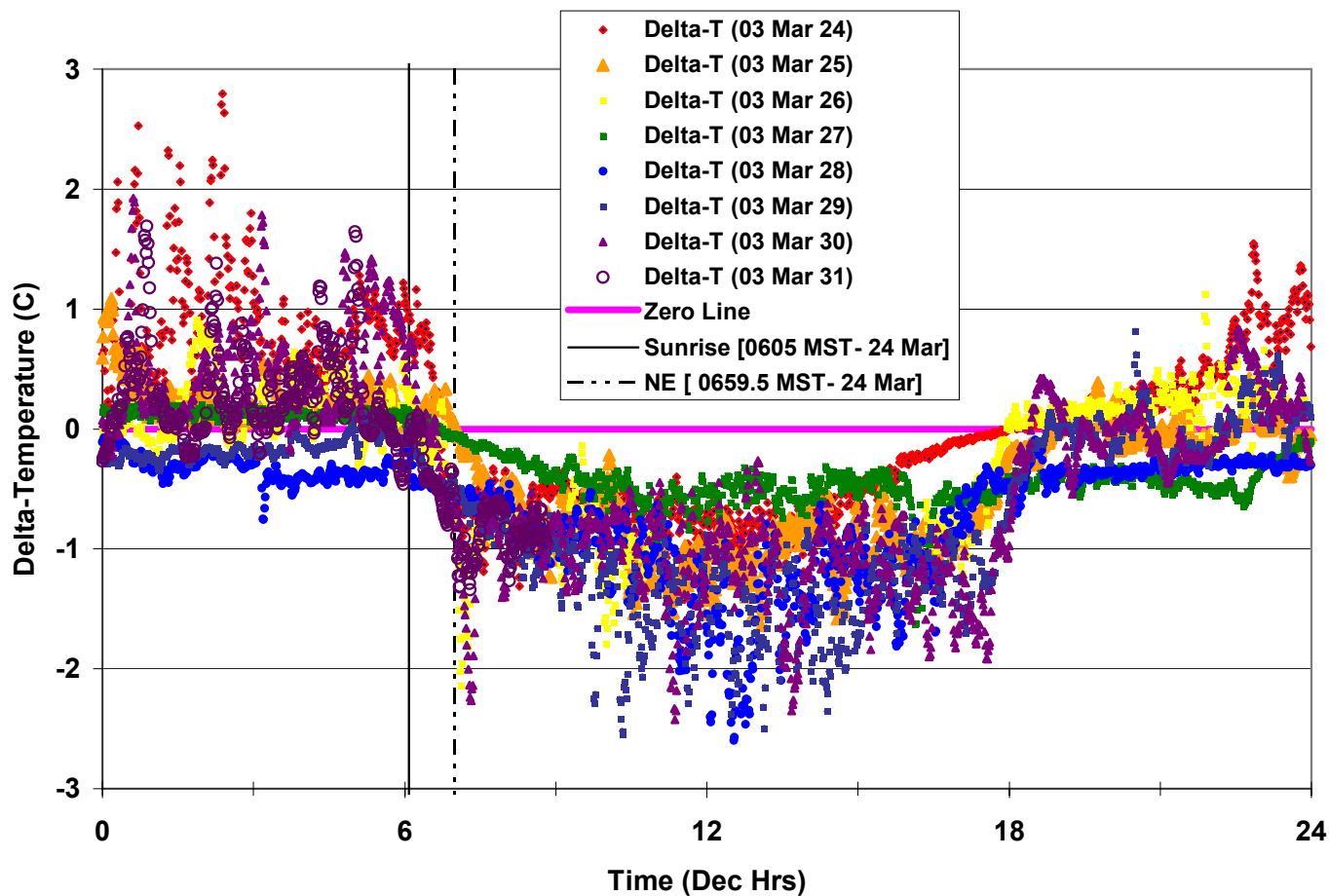
2003 Mar 25-31



3. 2003 March: Phase I Results Reviewed.

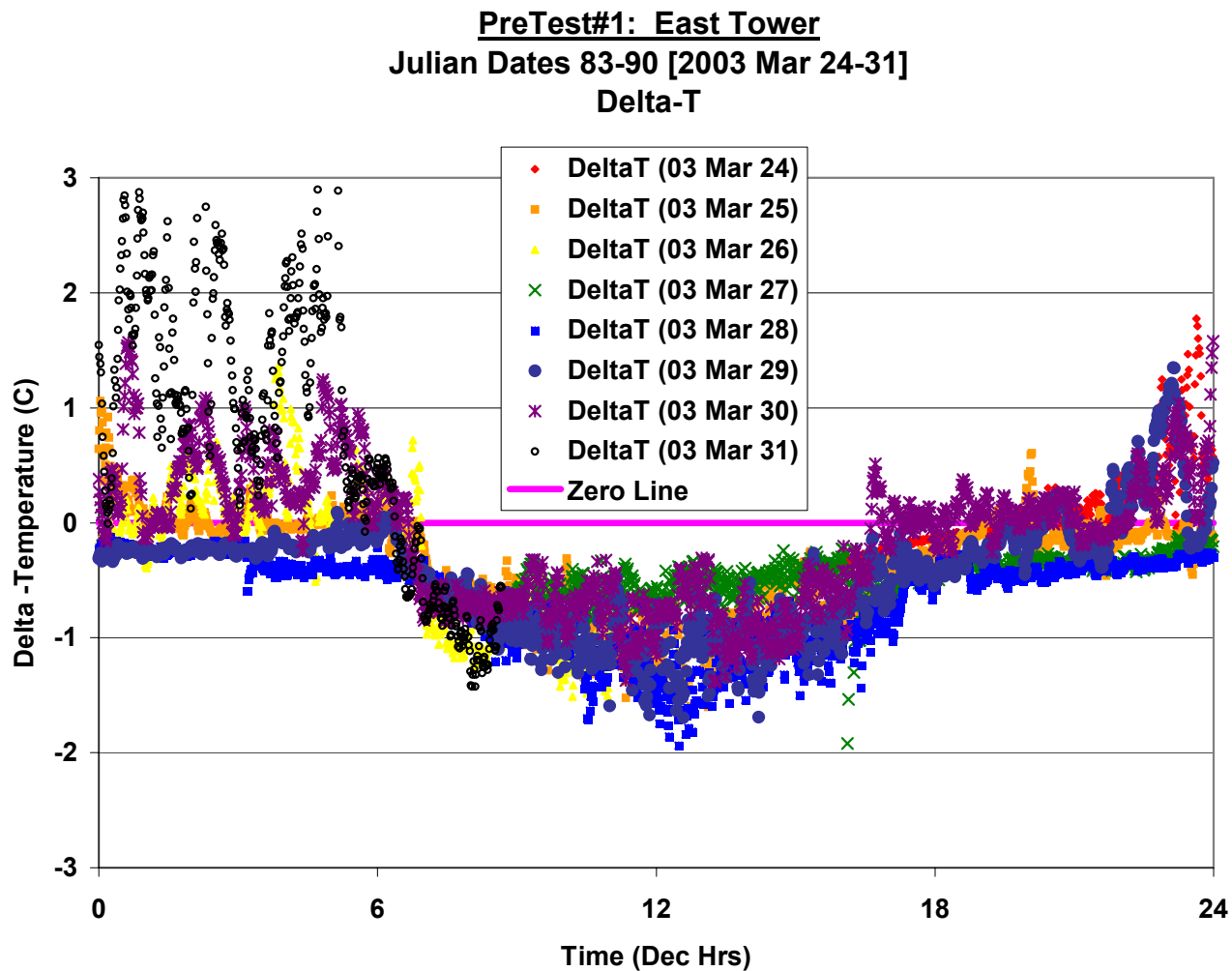


PreTest#1: South Tower
Julian Dates 83-90 [2003 Mar 24-31]
Delta - T





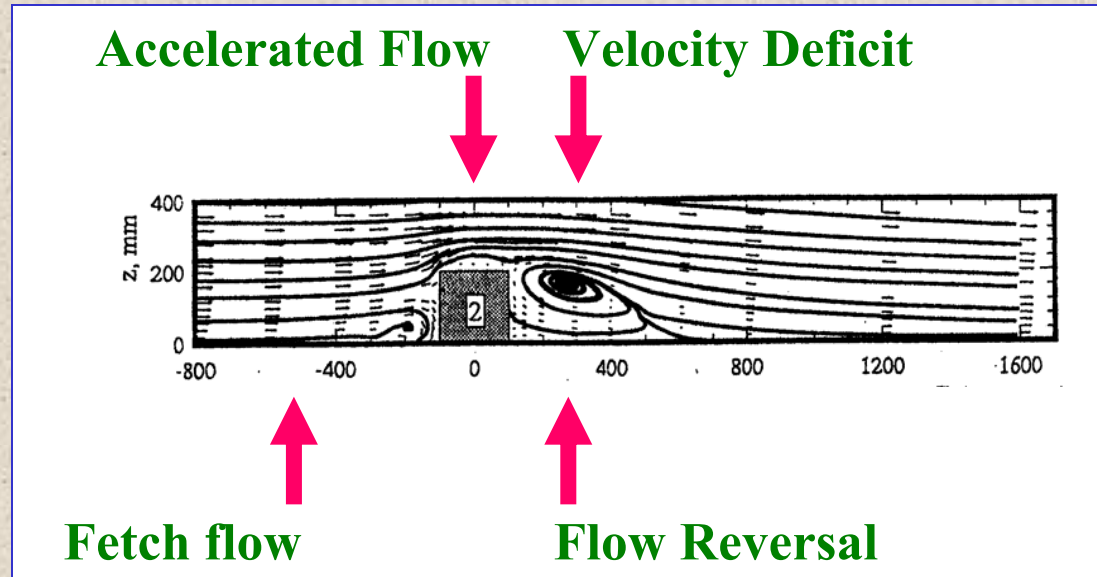
3. 2003 March: Phase I Results Reviewed.



3. 2003 March: Phase I Results Reviewed.

➤ Air Flow Results:

- Validated Specific Wind Tunnel Air Flows Features.
- Single building affects air flow patterns.



➤ Stability Transition [ST] Results:

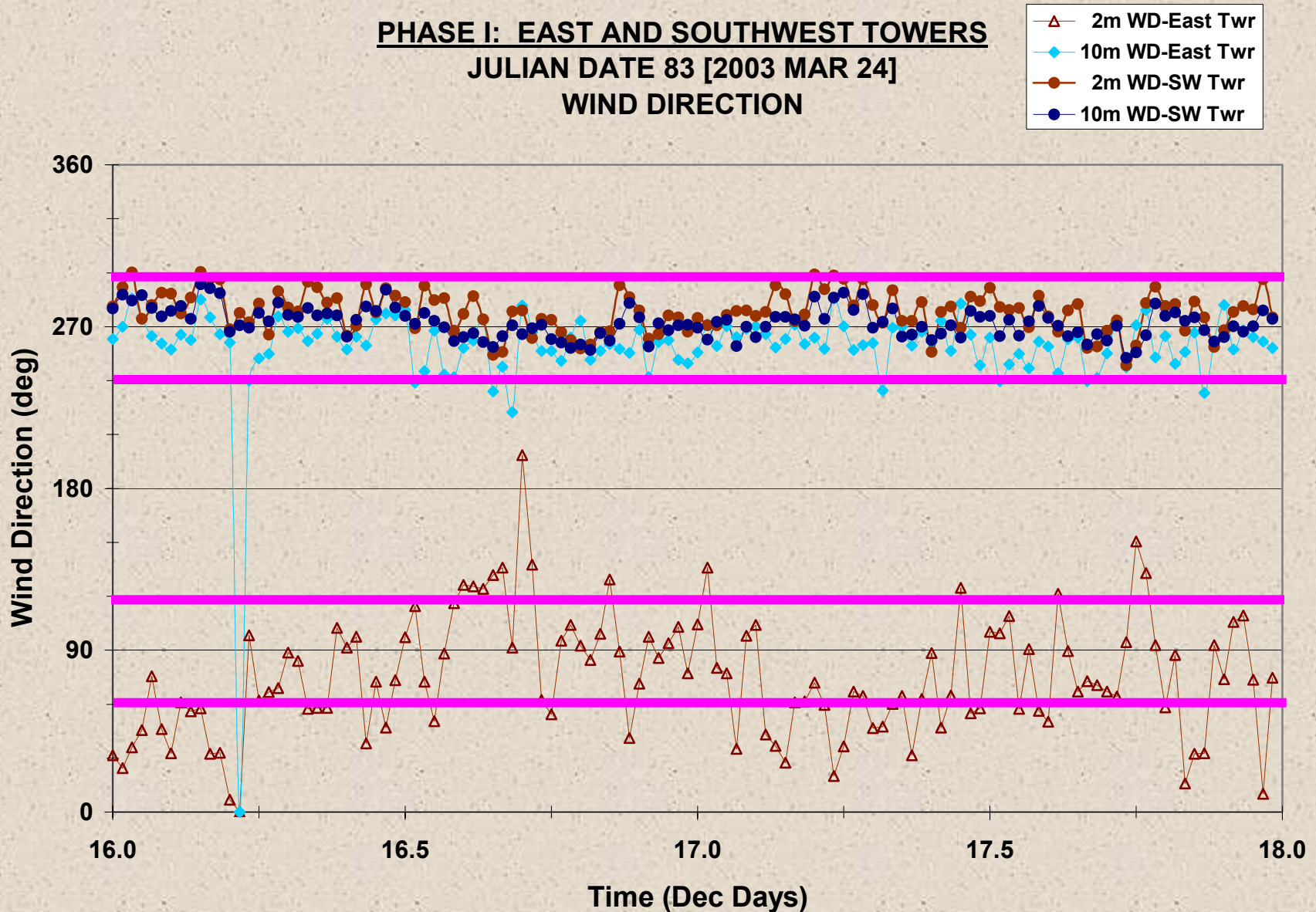
- ST results characterize an Urban Heat Island [UHI] effect.
- Small building complexes can retain some rural atmospheric character.

4. 2003 March: Phase II (Background)

PHASE I: EAST AND SOUTHWEST TOWERS

JULIAN DATE 83 [2003 MAR 24]

WIND DIRECTION





4. 2005 March: Phase II (Study Specifications).



- ➔ **March 2003: Mean Meteorological Conditions.**
- ➔ **March 2005: Flow and Stability under Turbulent Conditions.**
- ➔ **Mission Objectives: to characterize urban Airflow and Stability Patterns around and above a single building.**
- ➔ **Field Study Design:**
 - **Location-** Single, 2-story, rectangular, concrete-block office building.
 - **5 Meteo Towers-** 10m N-,S-,E-,and W-sides; 5m roof.
 - **Tower Placement-** Synder & Lawson wind tunnel study.
 - **Sensors-** Sonic and Campbell Systems.
 - **Variable-** P, T, RH, WS/WD, Solar Radiation.



4. 2005 March: Phase II (16 Sonics Added).

1 Minute Averages



20Hz Sampling Rate





WSMR Urban Study

BUILDING and TOWERS

SW

S

Roof

N

E

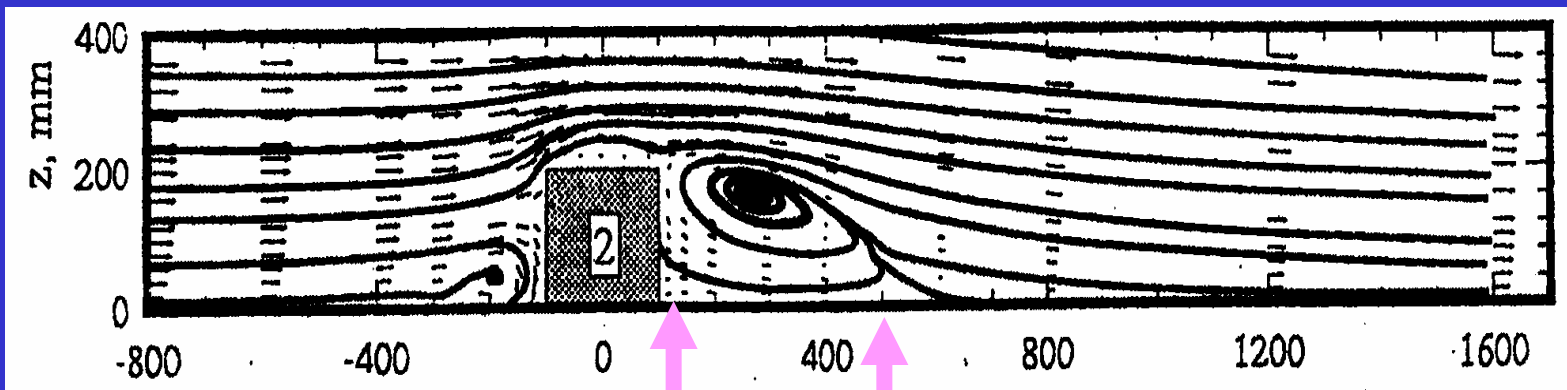




2. WSMR Urban Study

Accelerated Flow

Velocity Deficit



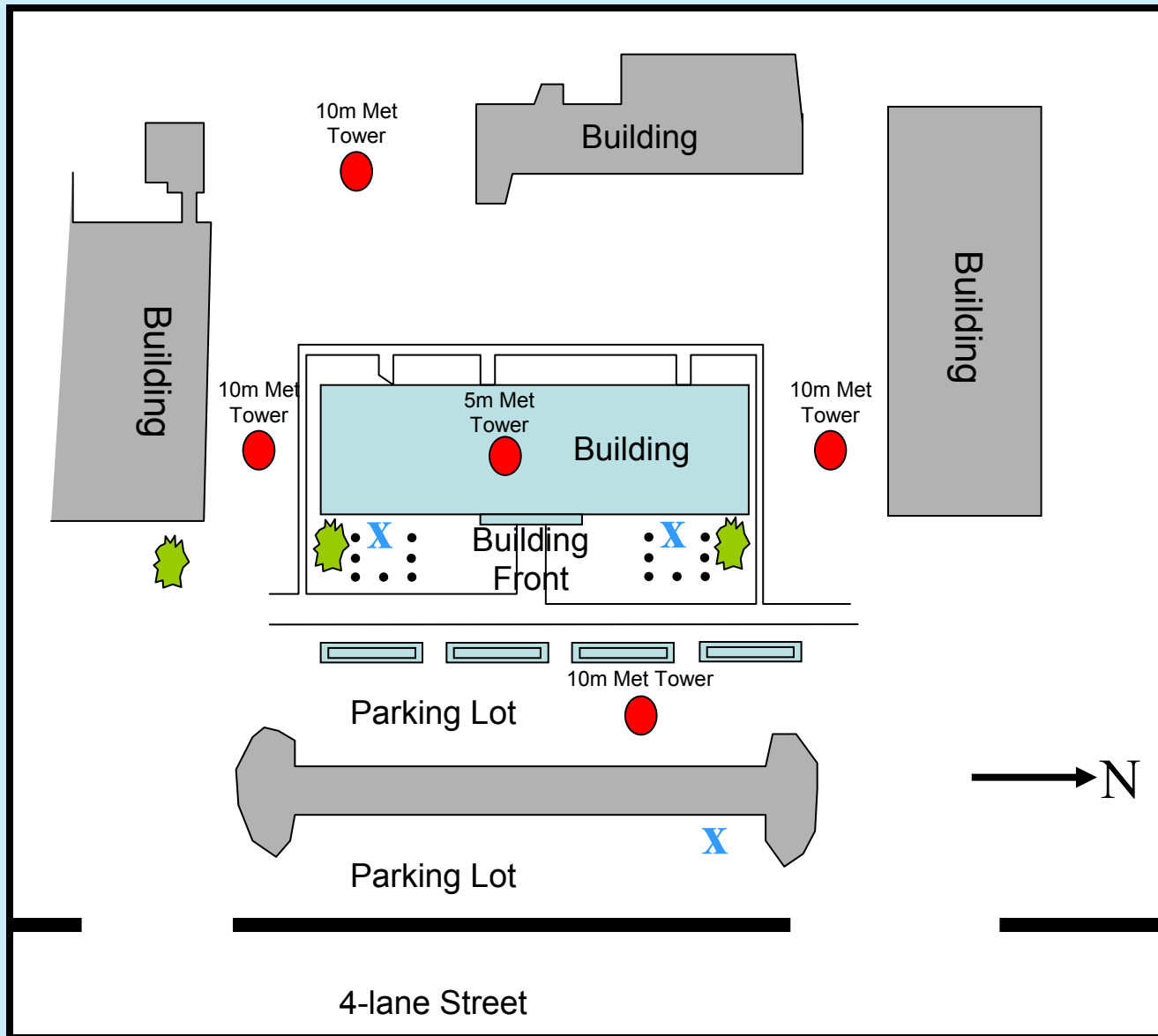
Leeside Eddies

Re-attachment Zone

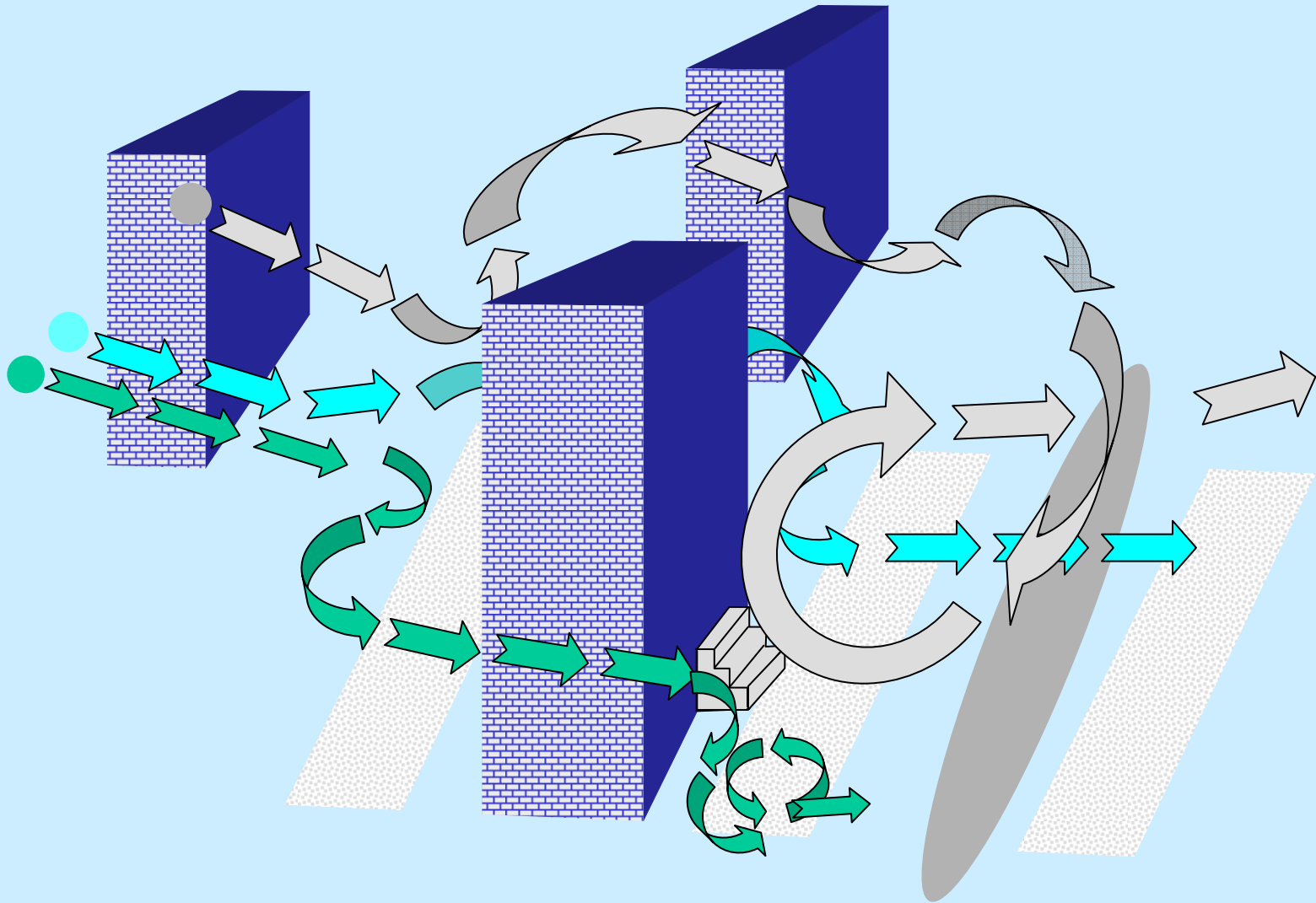
Fetch flow

Flow Reversal

Phase II: Field Site Layout (Not drawn to scale)

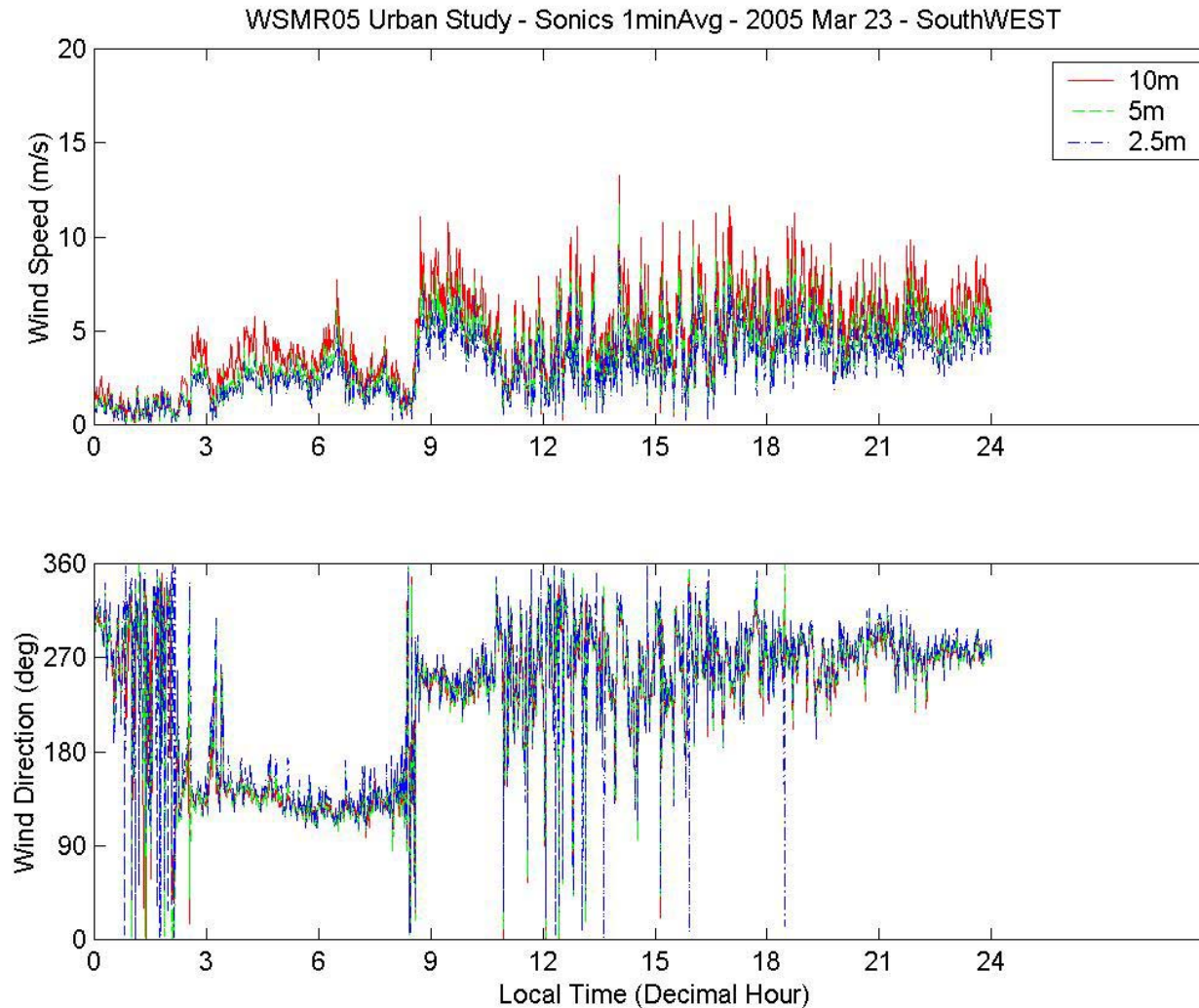


4. 2005 March: Phase II (Turbulent Conditions).



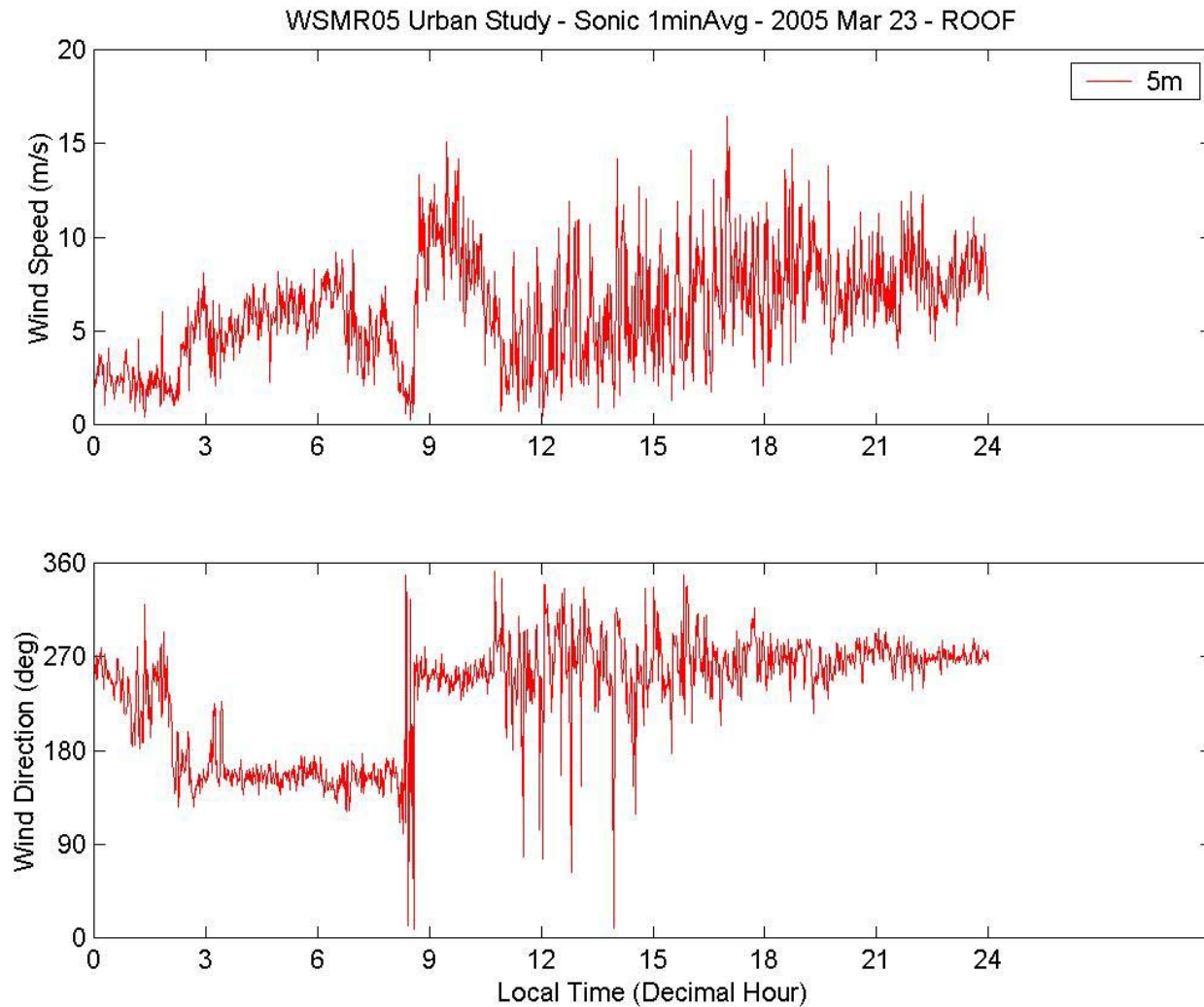
4. 2005 March: Phase II Preliminary Results.

“THE FETCH”



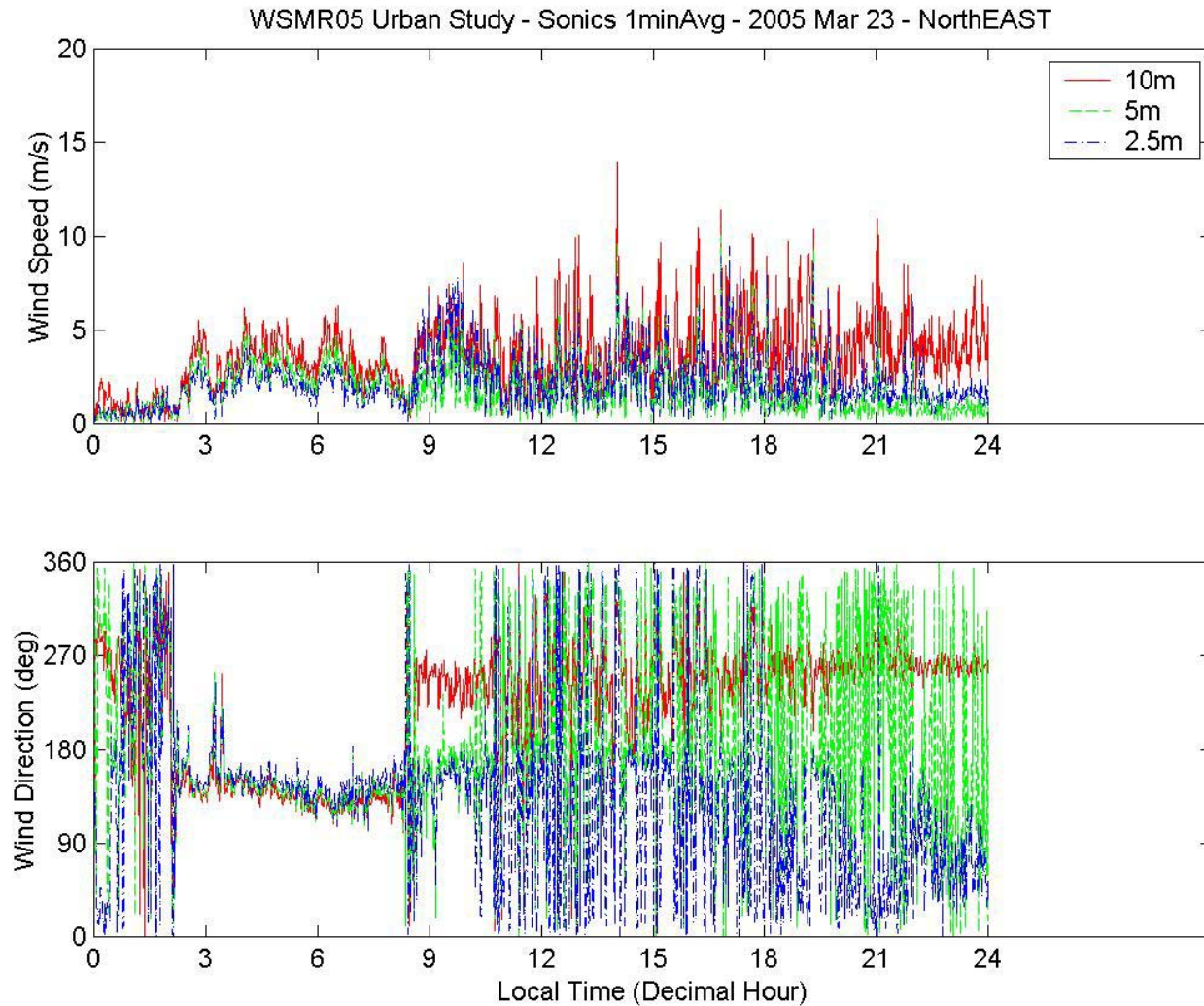
4. 2005 March: Phase II Preliminary Results.

“THE ROOF”



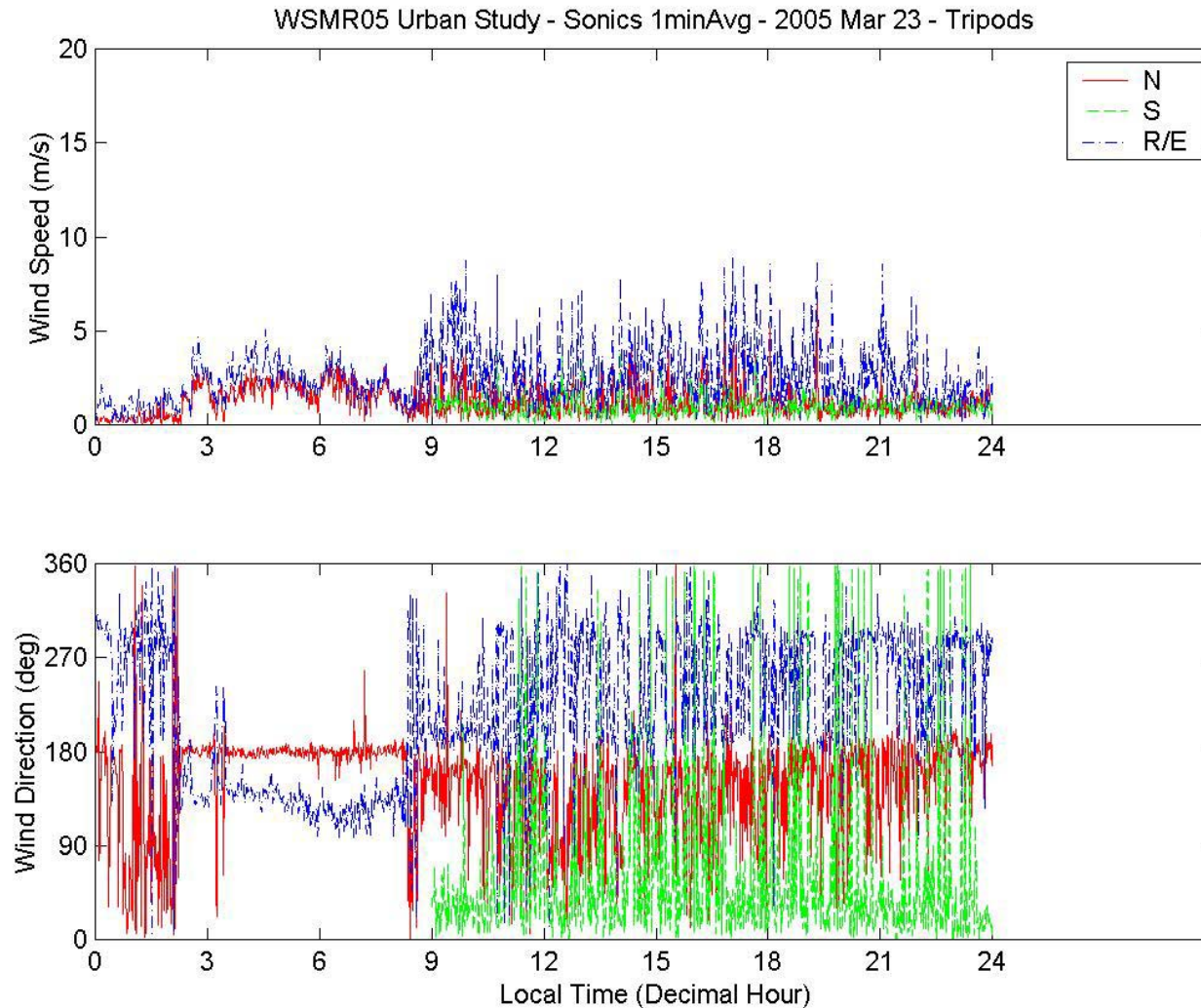
4. 2005 March: Phase II Preliminary Results.

“THE CAVITY”

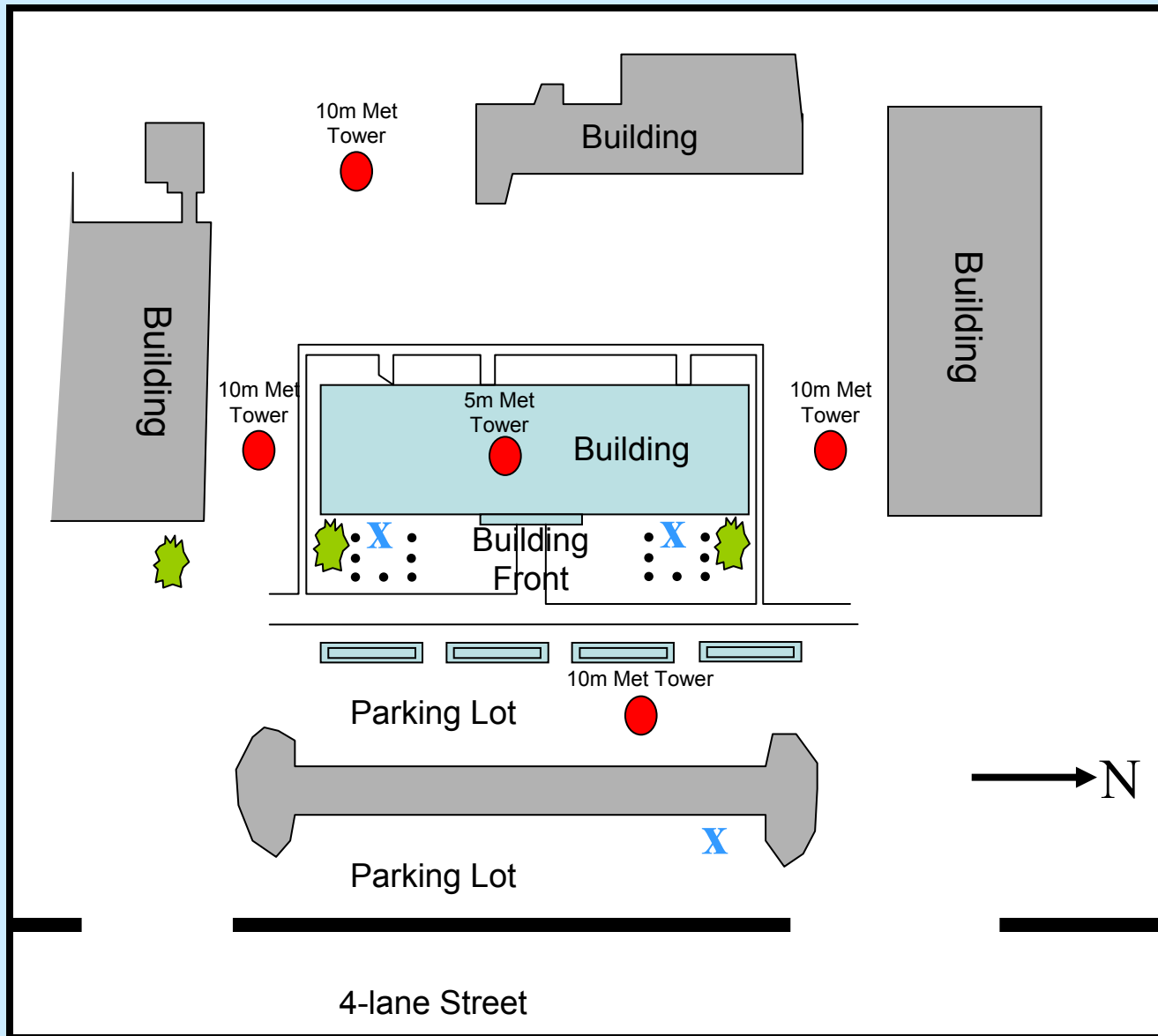


4. 2005 March: Phase II Preliminary Results.

“THE RE-ATTACHMENT and LEESIDE EDDIES”



Phase II: Field Site Layout (Not drawn to scale)





4. 2005 March: Phase I Preliminary Results.

⇒ Urban Simulations - usually use Neutral temperature profiles.

⇒ Lessons learned:

Cases

Day(Small bldg complex)

Night(Small bldg complex)

Implied Lesson Learned:

Day(City-large bldg complexes)

Night(City-large bldg complexes)

Temperature profile

Use Neutral and Unstable.

Use Stable, Neutral and Unstable.

Use Neutral and Unstable.

Use Neutral and Unstable.

⇒ Military Application:

CBN toxic corridors – maximizes effects with traditional Neutral profiles.

Optical propagation – minimizes effects with Neutral profiles.

– maximizes effects with Unstable profiles.

Need to include Unstable (and Stable) cases in Urban simulations.



4. 2005 March: Phase II Preliminary Results.



DYNAMIC Urban Atmospheric Effects

- ⇒ One Building does Disturb Airflow.
 - ⇒ Accelerated flow over building.
 - ⇒ Velocity Deficit Downwind.
 - ⇒ Flow Reversal in the Lee.
 - ⇒ Channeling Flow.
 - ⇒ Corner Vortices and Re-attachment Zone detected.
- ⇒ Vortex generation/degeneration – based on
Wind Direction, Wind Speed Range and Stability factors.

Implication for modeling/simulations....

Diffusion about Buildings

**Corner vortices lead to elevated concentrations on building leeward side.
Aid in placement of bio-detection sensors inside MOUT.**



Questions?

Phase II

2005 March

