U.S. Army Research, Development and Engineering Command

8th Symposium on the Urban Environment and the *Boundary Layers and Turbulence Committee*

Joint Session 11 - *Urban Canopy and Roughness Sub-layers*

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Paper J11.5A

Eight Stable Urban Environment Characteristics

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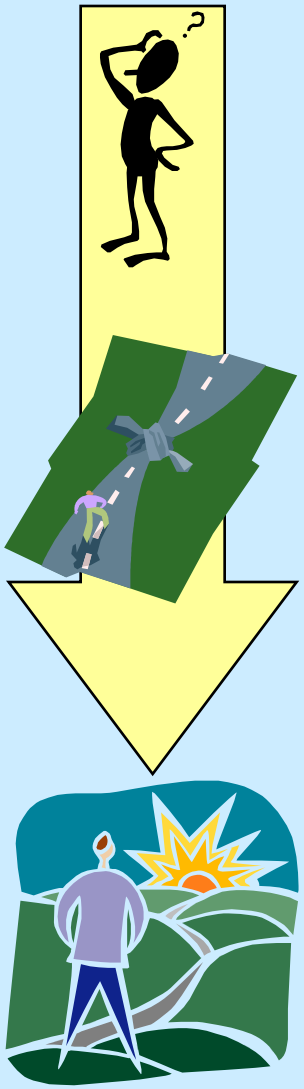
Urban Canopy and Roughness Sub-layers

1. Roughness Sub-layer = lowest atmospheric layer immediately adjacent to a surface covered with relatively large roughness elements such as stones, vegetation, trees, or buildings. Flow is three-dimensional and site-dependent.

2. Turbulence properties and scalar transport (including deposition) may vary with the surface type and texture.

3. In general, Monin-Obukhov (M-O) similarity theory is not applicable within the roughness sub-layer, as **turbulence and local circulations are strongly affected by individual roughness elements**. The transport of passive scalars (e.g., CO2, water vapor, other trace gas species, and aerosols) can be quite different from dynamical quantities such as temperature and momentum.

4. Turbulent eddies in roughness sub-layers are particularly anisotropic and highly intermittent in space and time, especially under stable situations. The complicated nature of turbulence within the roughness sub-layer also dramatically influences chemical reaction rates.



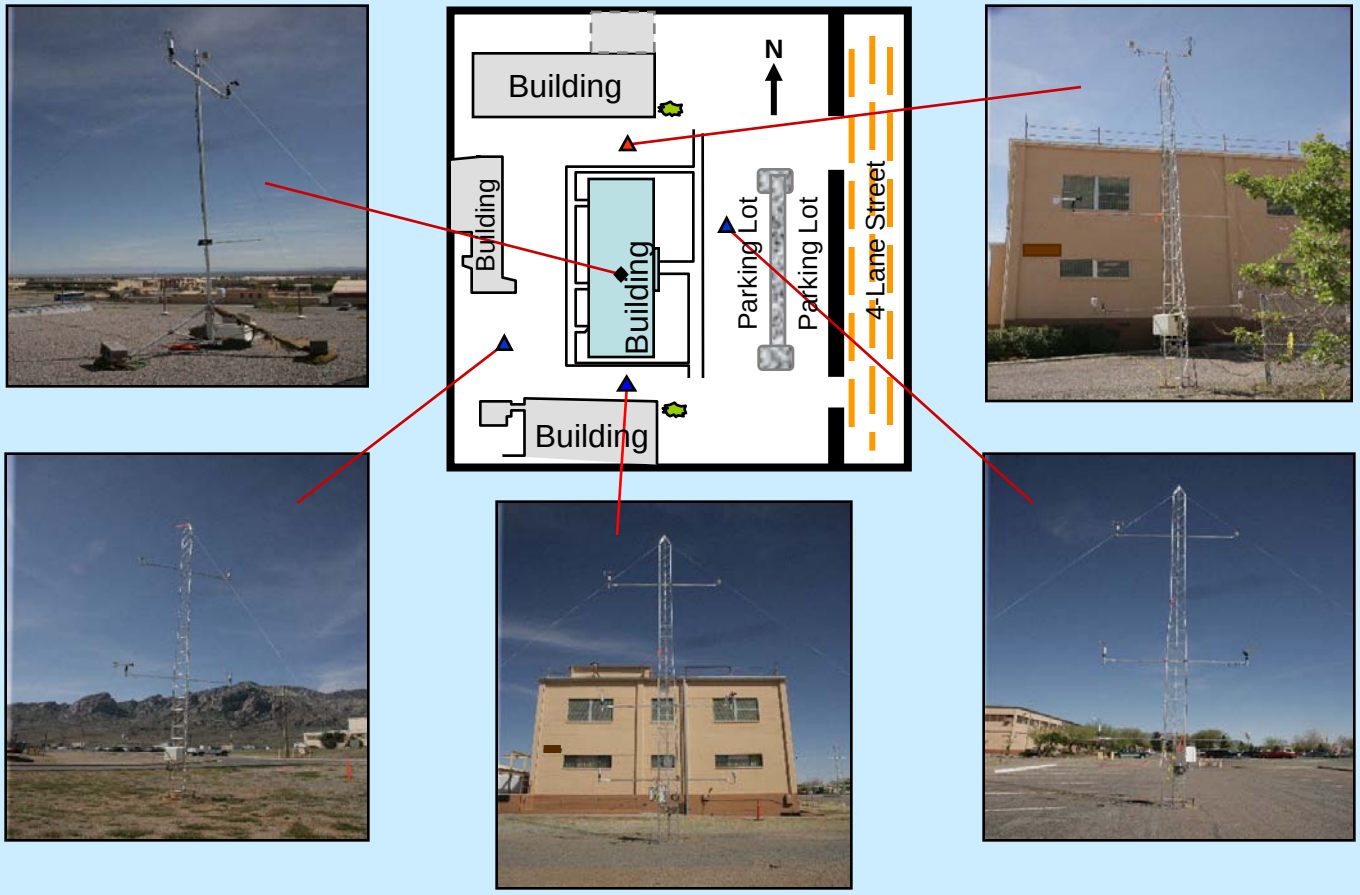
Eight Stable Urban Environment Characteristics

1, 2 - The American Meteorological Society Glossary, CD-ROM, 2000.
3, 4 - Geophysical Turbulence Program Workshop - Turbulence and Scalar Transport in Roughness Sub-layers
http://www.image.ucar.edu/Workshops/GTPSep2006/

Inter-comparison of Stability Characteristics from Three Urban Single Building Field Studies

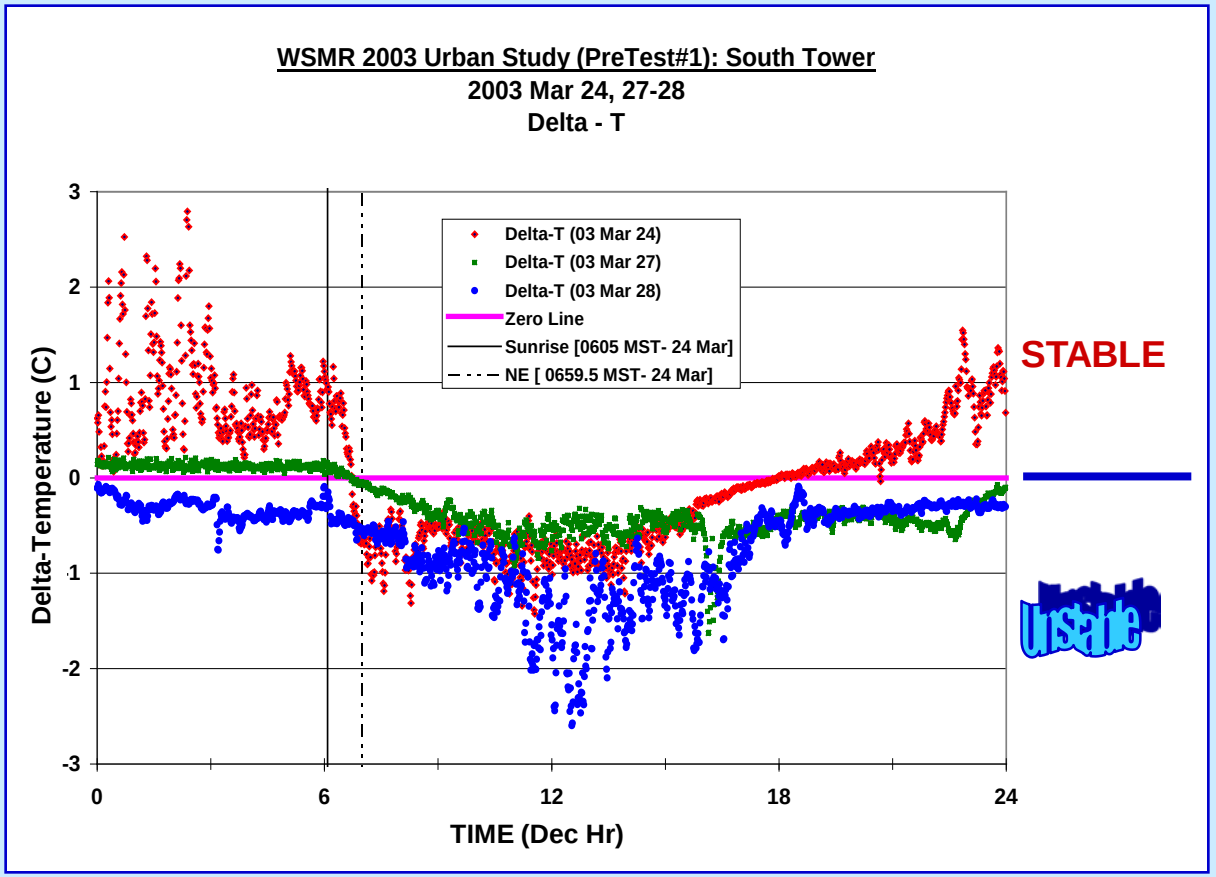
Location: Southern New Mexico.

Field Studies: WSMR 2003 Urban Study (W03US) – 2003 March
WSMR 2005 Urban Study (W05US) – 2005 March
WSMR 2007 Urban Study (W07US) – 2007 March



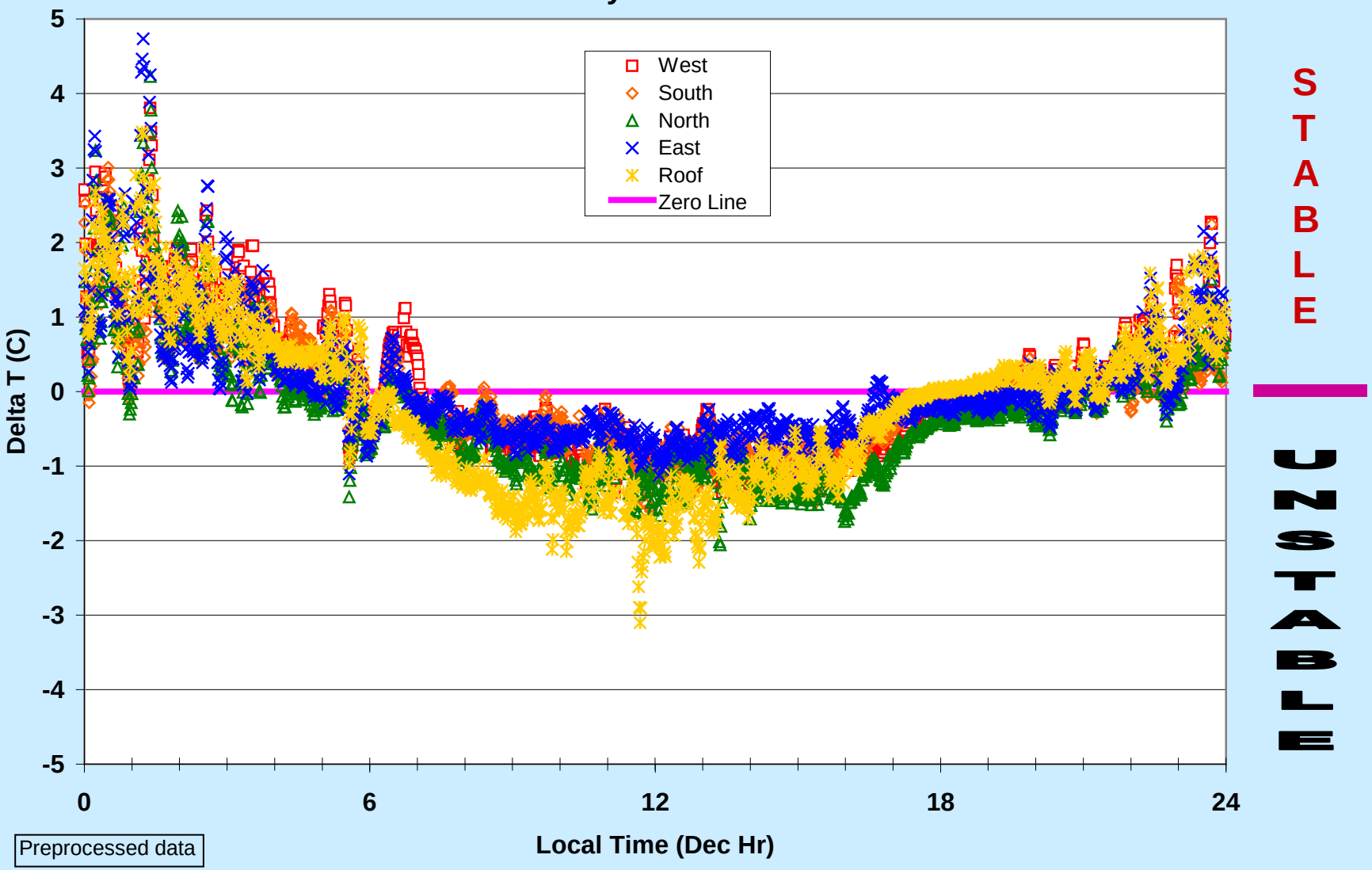
Urban Stability in a Small Building Complex

Typical Urban Stability: Neutral and unstable atmospheric conditions.

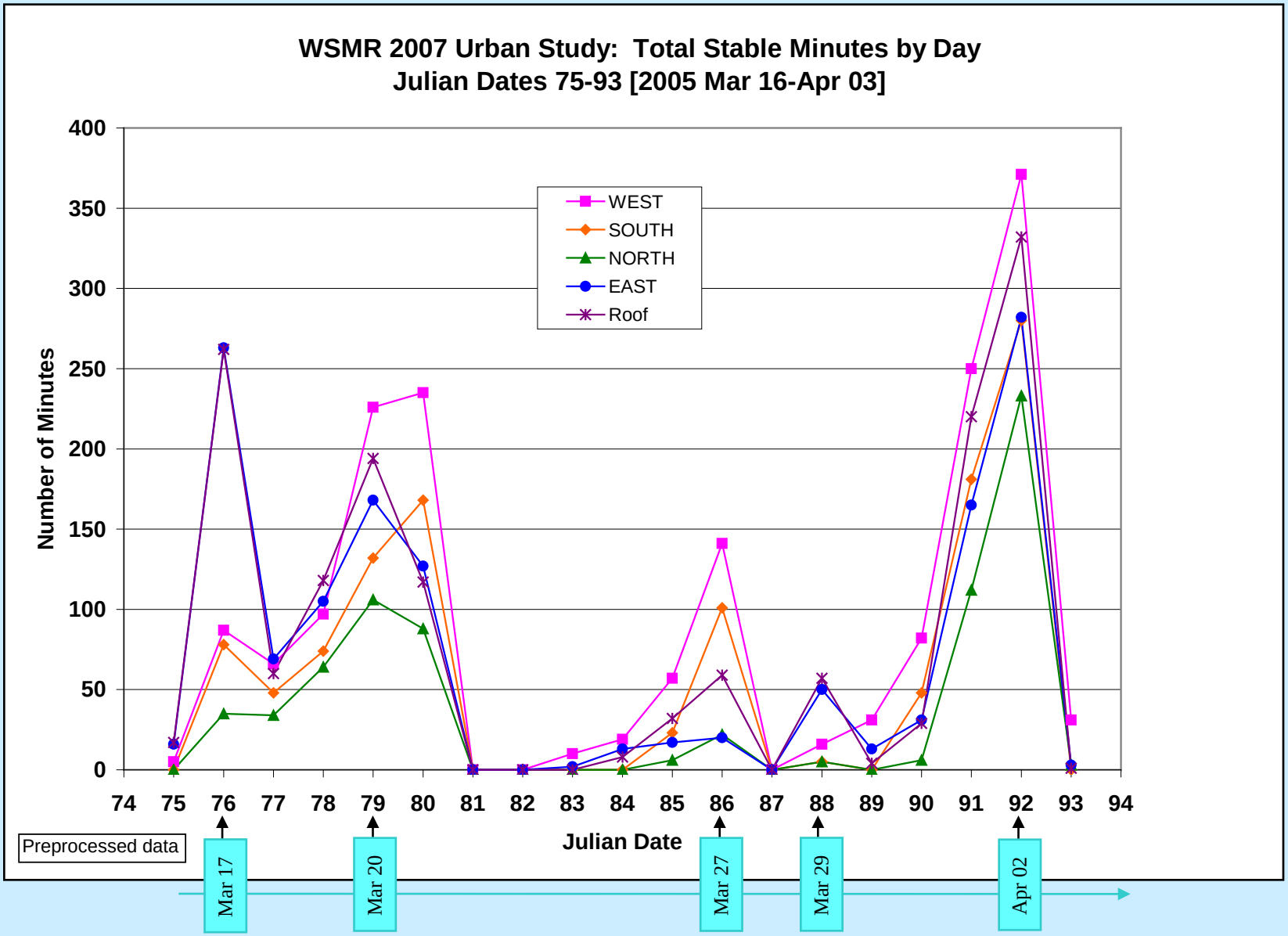


Field Studies reported: Neutral, unstable *and stable* atmospheric conditions.

Urban Stability in a Small Building Complex

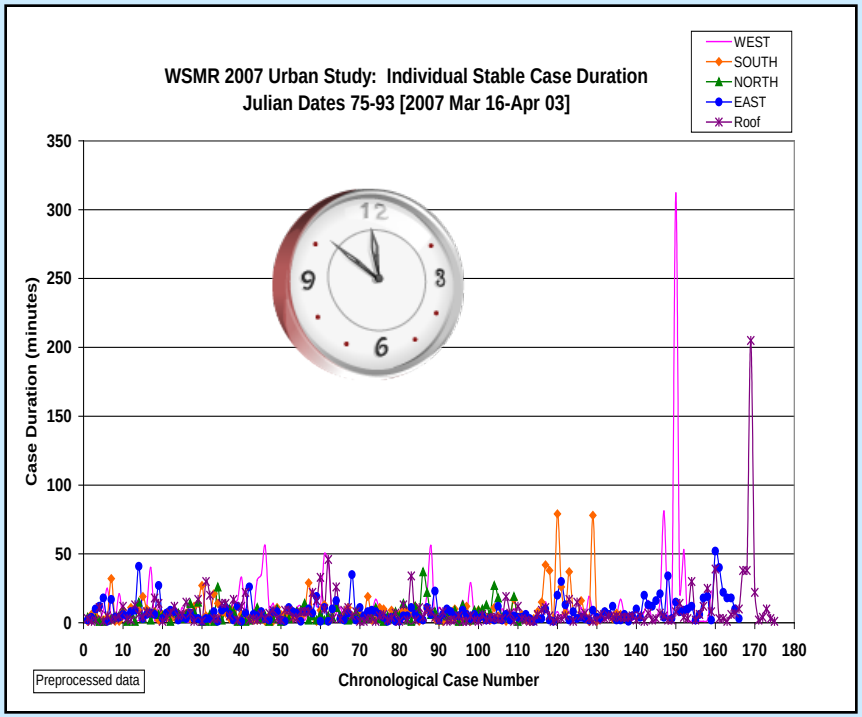


Stable environments occurred on all sides of a building

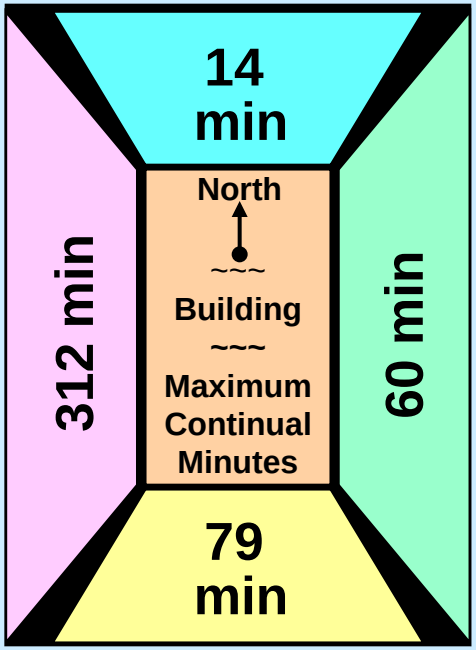


General Characteristics Observed in Urban Stable Environments

A 'Case': Greater than or equal to 1 min of stable conditions.



1. Duration of consecutive stable min averaged 6–8 min.
2. Extreme durations for consecutive stable minutes ranged 14–312 min.
3. Extreme stable case durations favored the light wind environments.

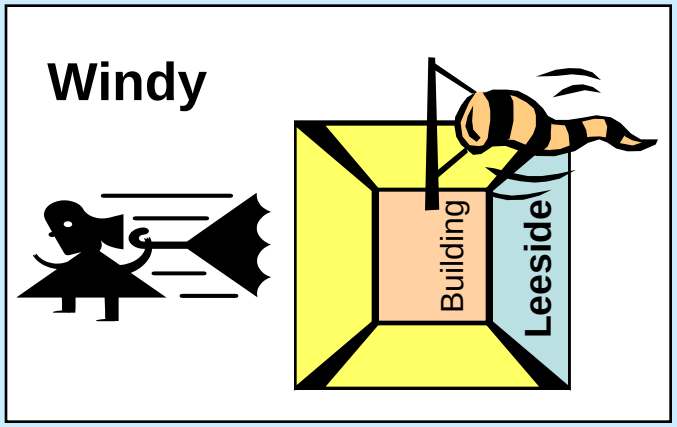


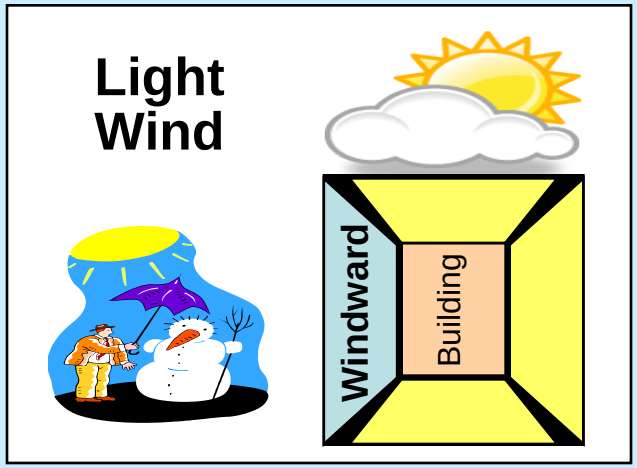
Max Case Lengths for the three *Studies*:

West	312 minutes
South	79 minutes
East	60 minutes
North	14 minutes

Spatial Characteristics

4. **During windy conditions, the building leeside was favored for a stable environment. The open leeside environment (also, a building wake area) suggests an increased potential for radiative cooling with respect to the other "enclosed" building sides.**



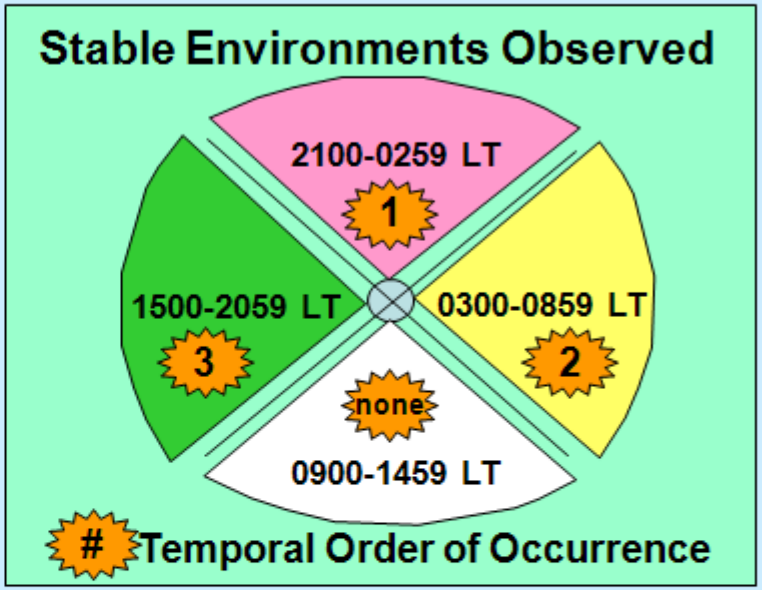


5. **During light wind conditions, the building windward was favored for stable conditions. Heat from the radiating building lacks the airflow necessary to send the heat away from the building. Therefore, all sides but the windward, integrate the added heat into the vertical profiles and report less stable conditions than the non-building-influenced Fetch side.**

Temporal Characteristics

6. Most populated stable environment period: Midnight, ±3 h.**
7. Second most populated stable environment period: Sunrise, ±3 h.

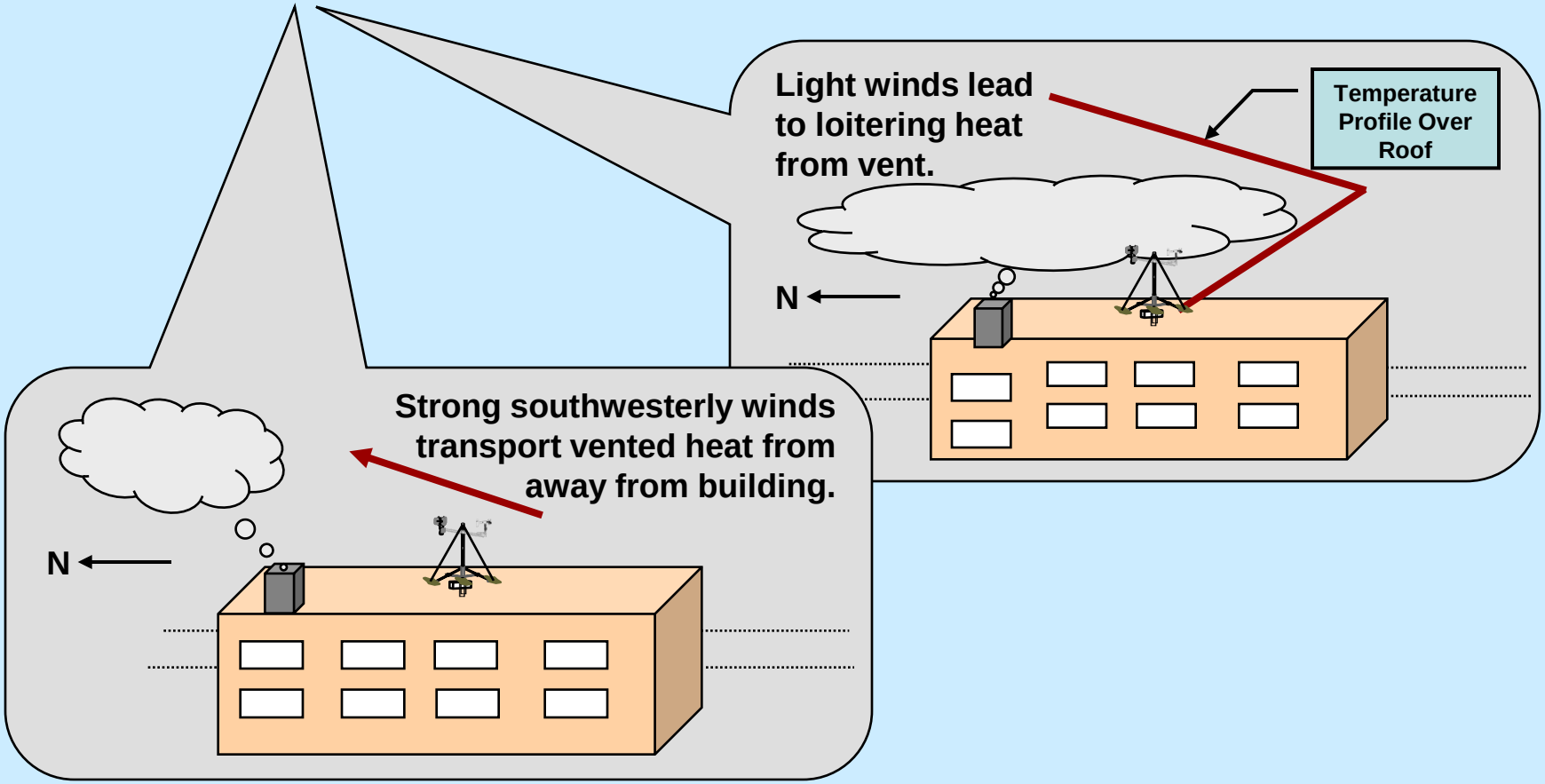
**Preliminary findings from subsequent research indicate that the most populated period may be refined to 0000–0300 LT.



Field Study	Sunrise 0300–0859 LT	Daytime 0900–1459 LT	Sunset 1500–2059 LT	Night Time 2100–0259 LT	Total (%)
W03US	44	0	0	56	100
W05US	44	0	6	50	100
W07US	28	0	6	66	100

Roof Stable Environment Characteristics

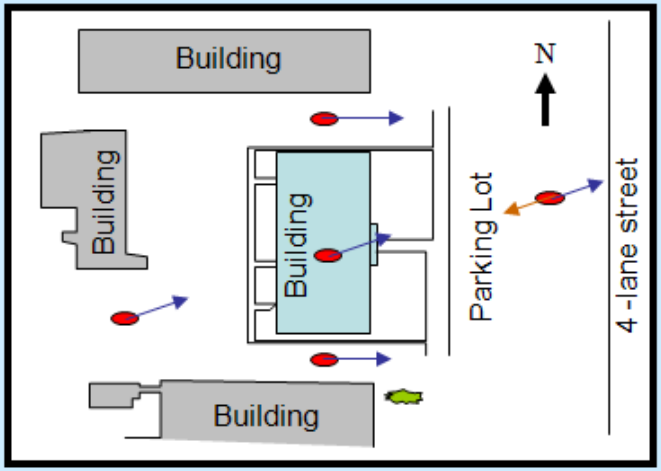
8. The roof with a heating vent generated a stable environment.

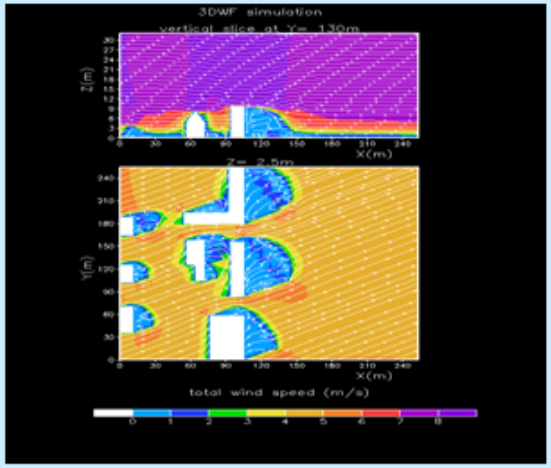


Light winds occurred during *W07US*. Without the anticipated southwesterly air velocities to carry the heat away from the building, the roof's atmosphere gained a warm air pocket that was picked up by the upper level sampler. The net result was that a stable roof environment was reported.

SUMMARY

1. The most populated period for stable environment occurrence was midnight, ±3 h.**
2. The second most populated period for stable environment occurrence was sunrise, ±3 h.
3. During windy conditions, the building leeside was favored for a stable environment.
4. During light wind conditions, the building windward (Fetch) side was favored.
5. The average duration of consecutive minutes for stable conditions was 6–8 min.
6. The extreme durations for consecutive stable minutes, as defined by the individual tower data, ranged from 14–312 min (312 min = 5 h 12 min).
7. Extreme stable case durations favored the light wind environments.
8. The roof with a heating vent generated a stable environment.





Questions?