Urban Meteorology

DCNet: ARL’s Urban Experience

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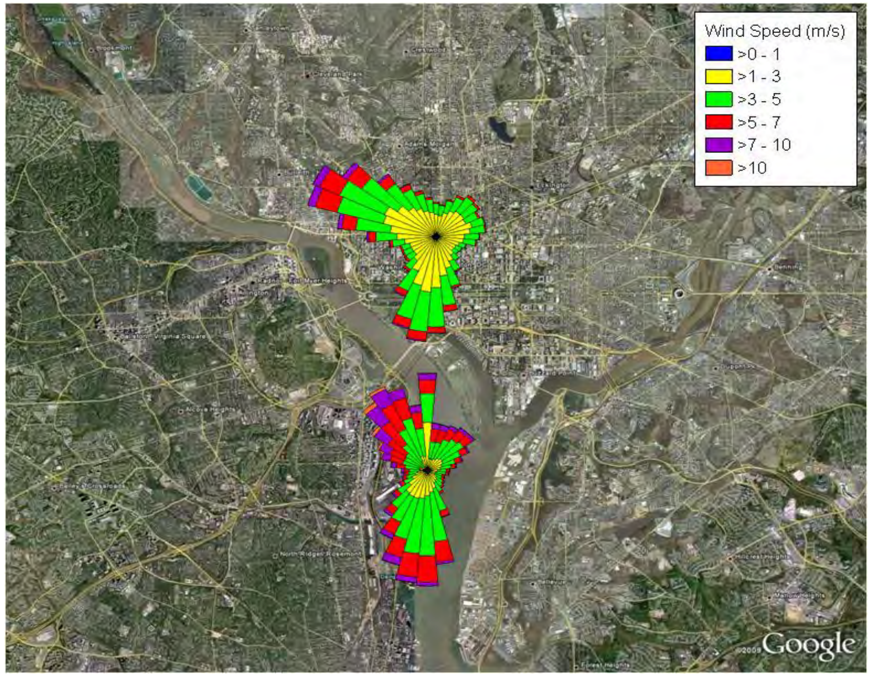
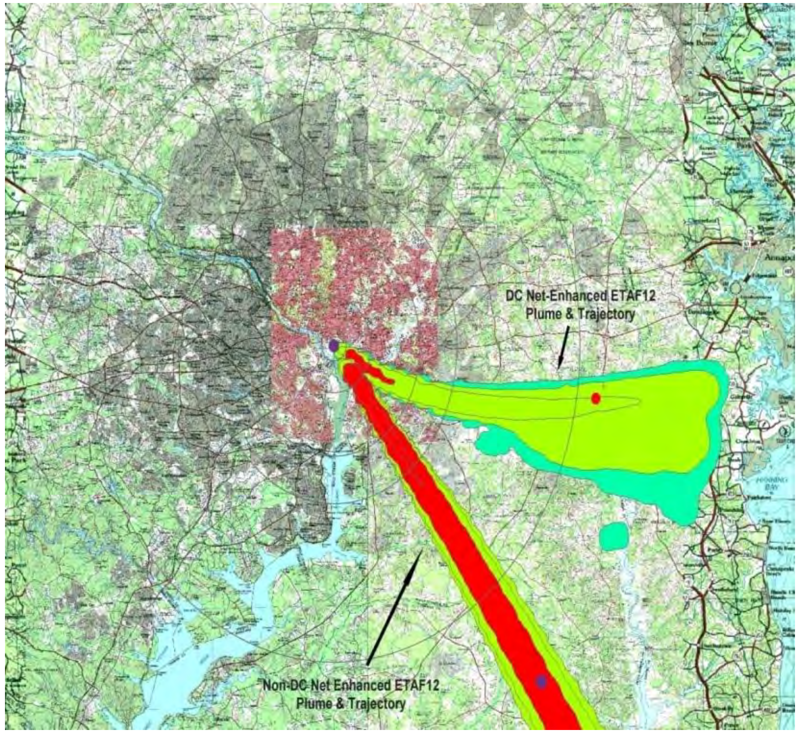
Science Question

Does assimilation of urban observations make a difference?

Improving parameterizations means collecting representative measurements! Long term record is needed to address the many complex temporal and spatial issues related to urban meteorology.

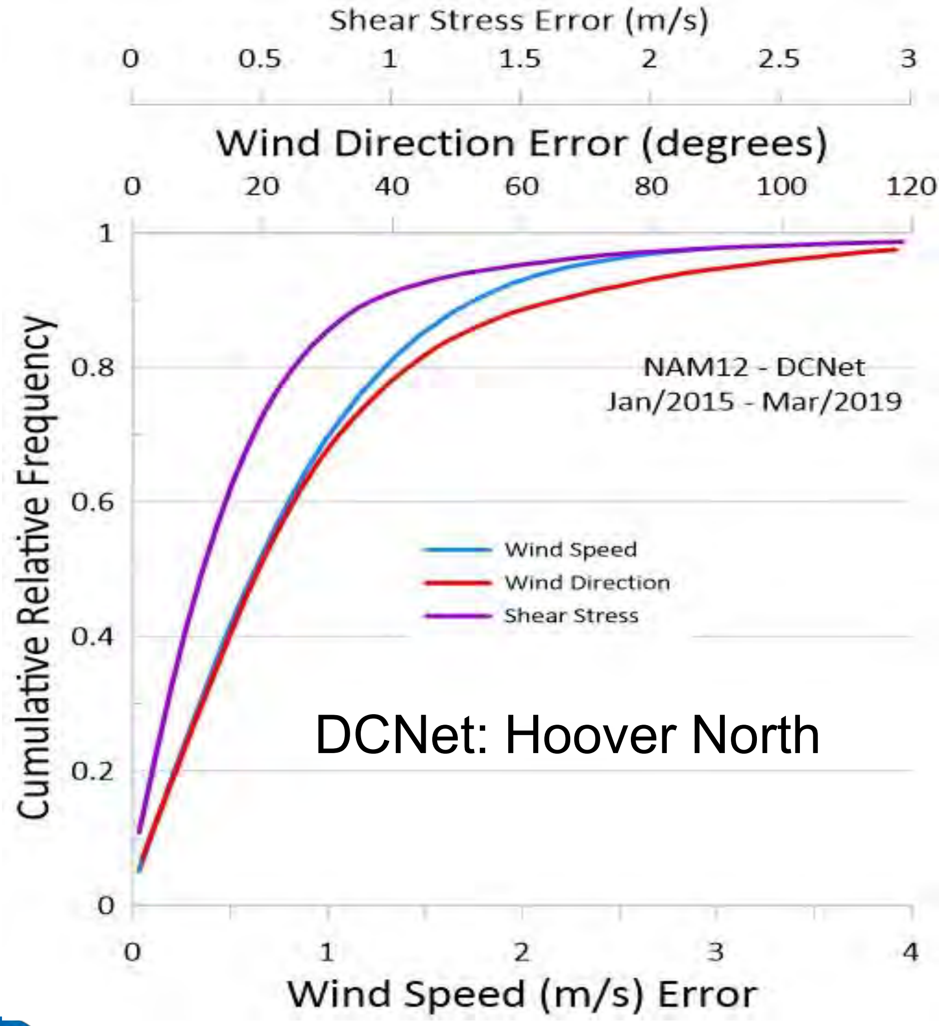




"Urban Test Bed: A multifunctional infrastructure that provides multi-year continuous measurements and archival of environmental data, across a metropolitan area and through the atmospheric boundary layer, supporting improvements in a range of activities from scientific research to user applications"

FCMSSR/Joint Action Group for the Joint Urban Test Beds (JAG/JUTB)

NWS NAM12 Model Evaluation
Model Prediction Error

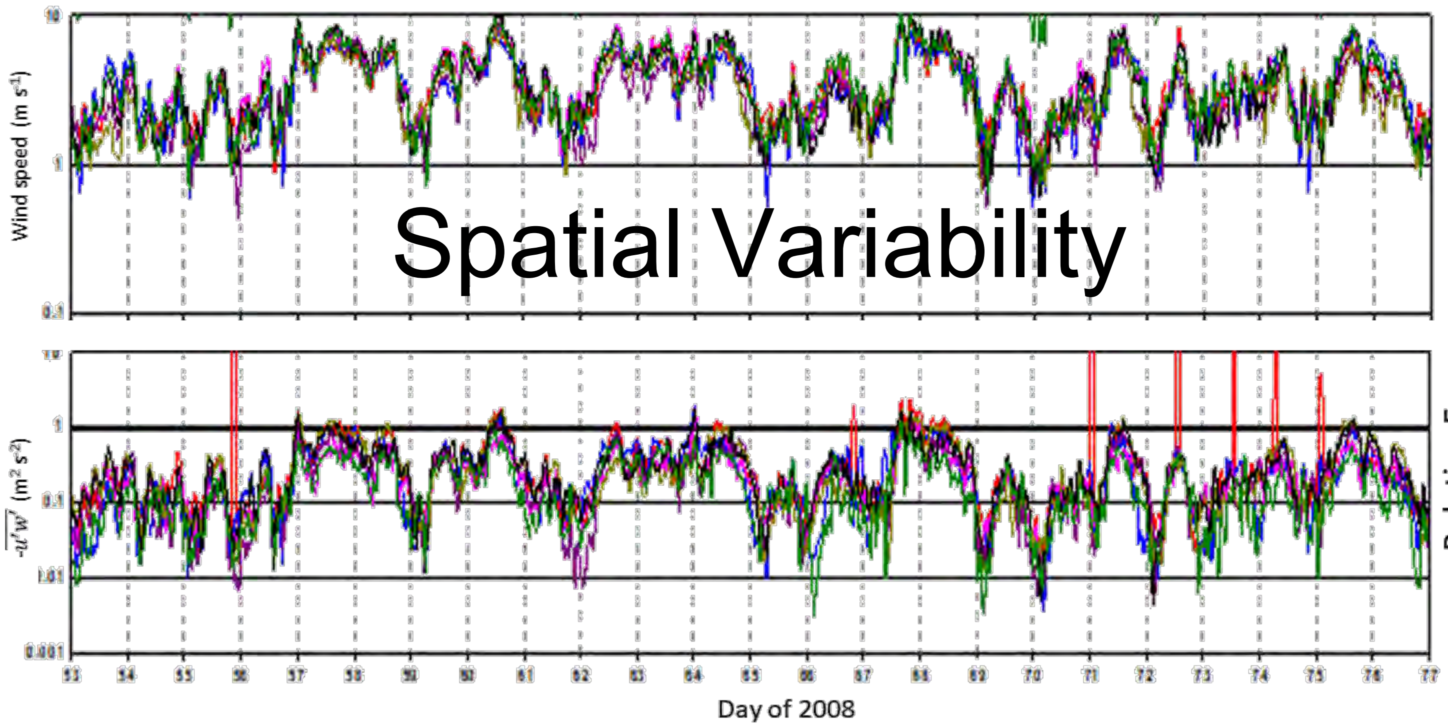


Percentile	+/- Wind Speed	+/- Wind Direction	+/- Normalized Shear Stress
1.0%	0.01	0.42	0.50%
5.0%	0.05	2.06	2.76%
10.0%	0.11	3.95	5.55%
25.0%	0.30	9.97	13.93%
40.0%	0.50	14.85	15.00%
50.0%	0.65	20.67	30.50%
65.0%	1.00	28.35	42.00%
75.0%	1.16	37.84	56.58%
90.0%	1.78	66.98	96.30%
95.0%	2.28	94.49	149.31%
99.0%	4.10	151.52	356.62%

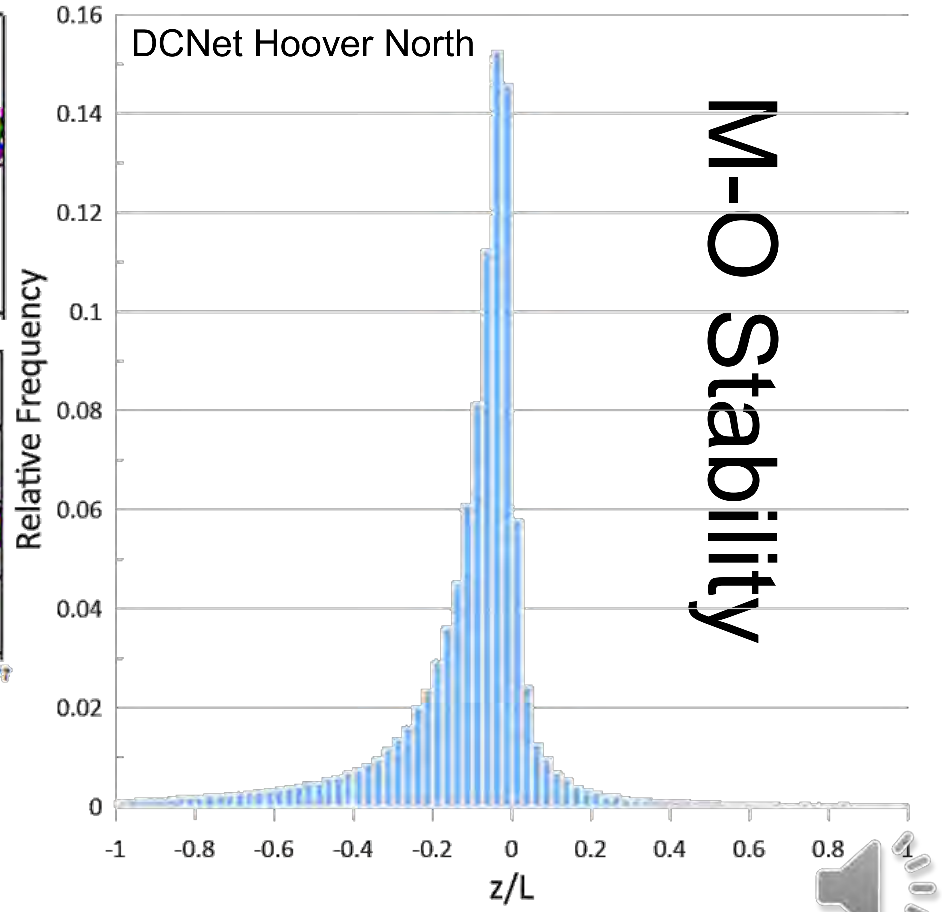
“In the near-field, atmospheric transport and dispersion models have a 50% probability of either over/under-predicting concentrations levels by three orders-of-magnitude.”

The National Capital Environment

"National Capital Region Can be Characterized as Near-neutral Skimming Flow"

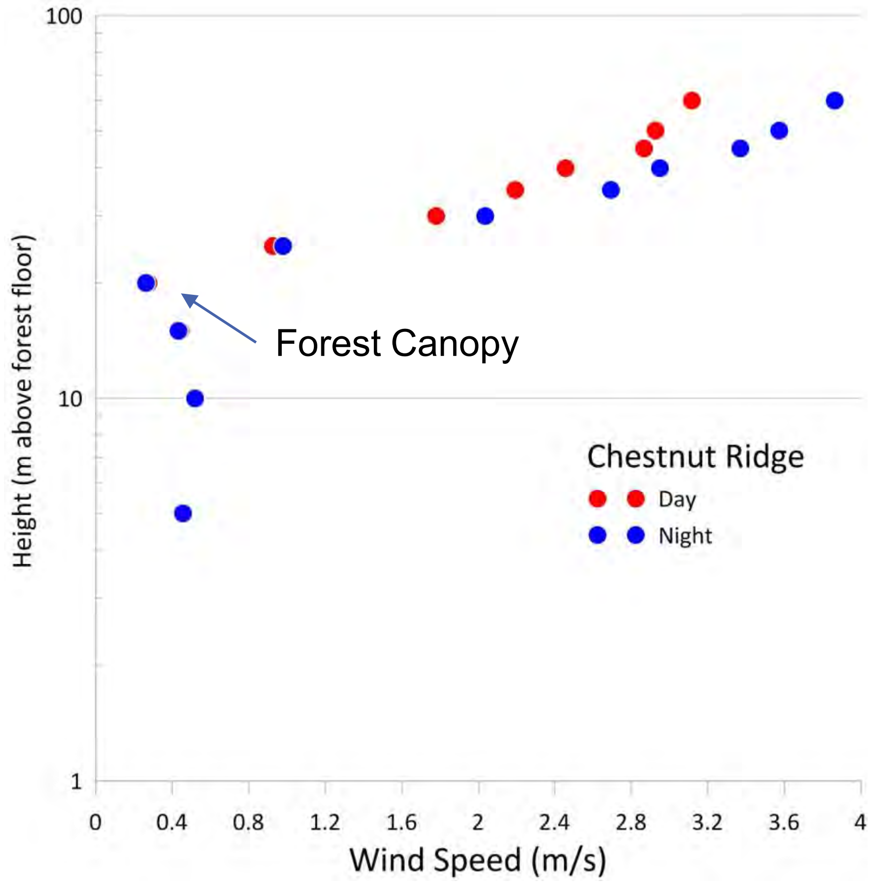


Wind Speed and Shear Stress Observations from 8 DCNet flux stations operating within the National Capital region



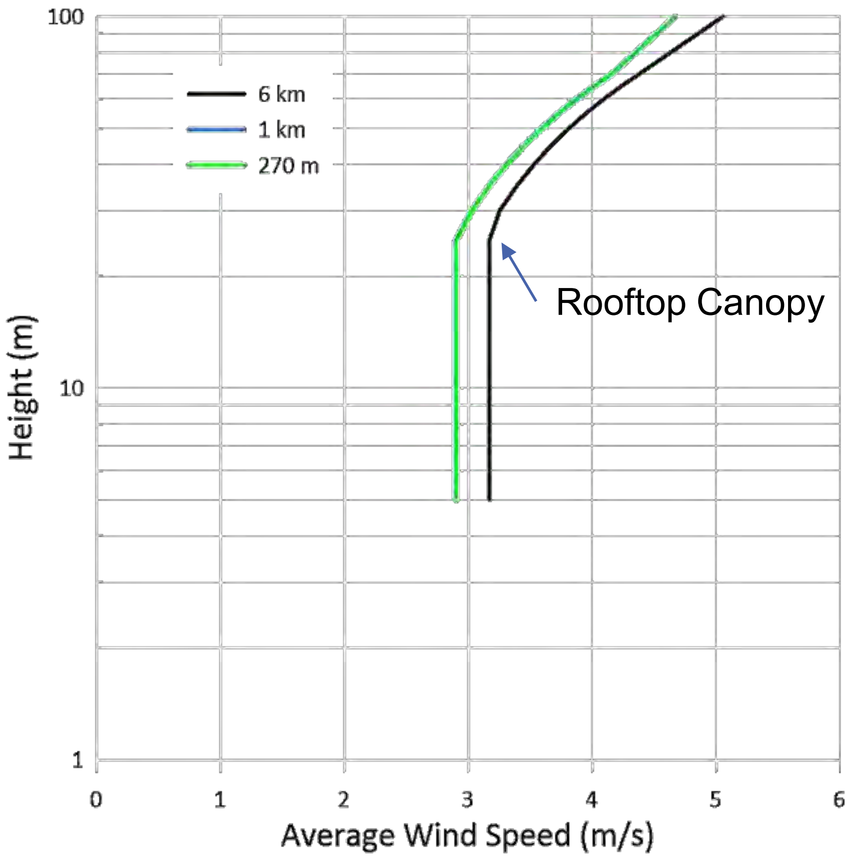
Modeling Urban and Forest Canopies
Modeling the Mean Flow

ARL Chestnut Ridge Forest Research Station



Links Between Forest And Urban Modeling

ORNL High Performance Computing Simulation of DCNet Hoover

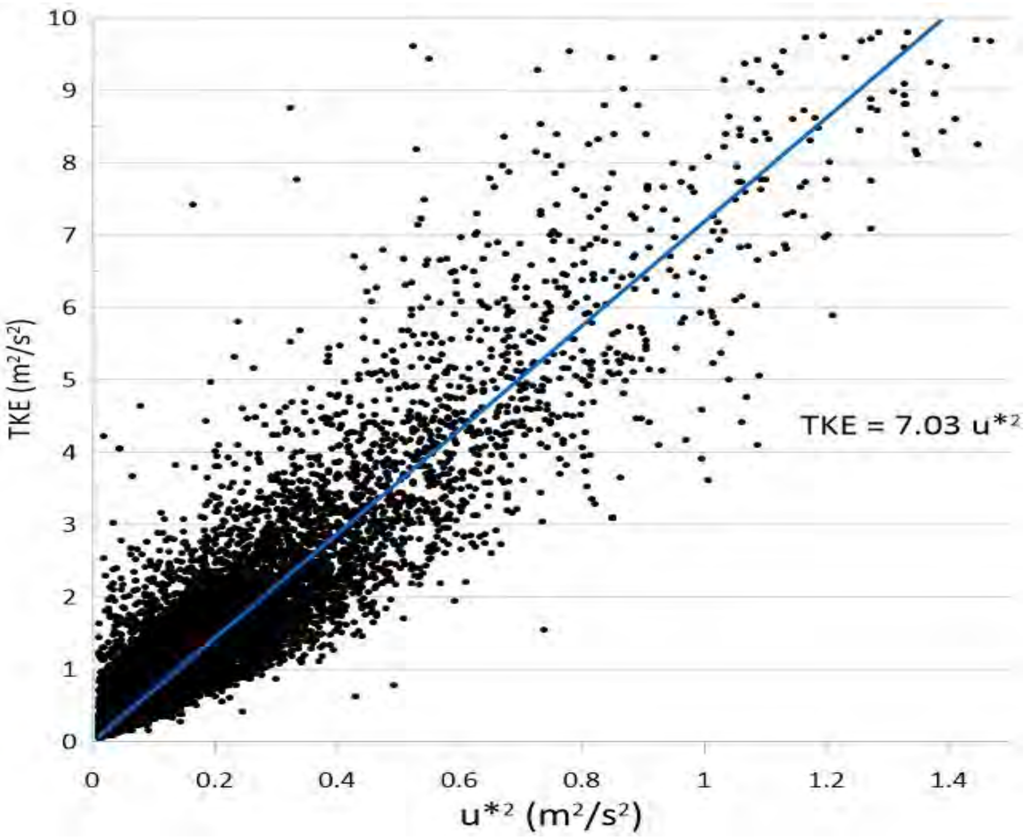


Modeling Urban Turbulence
Extension of Skimming Flow

	TKE/u_*^2	u'²/u_*^2	v'²/u_*^2	w'²/u_*^2
Garratt (1992)	5.46	5.76	3.61	1.56
DCNet Hoover	7.03	7.29	4.67	1.69

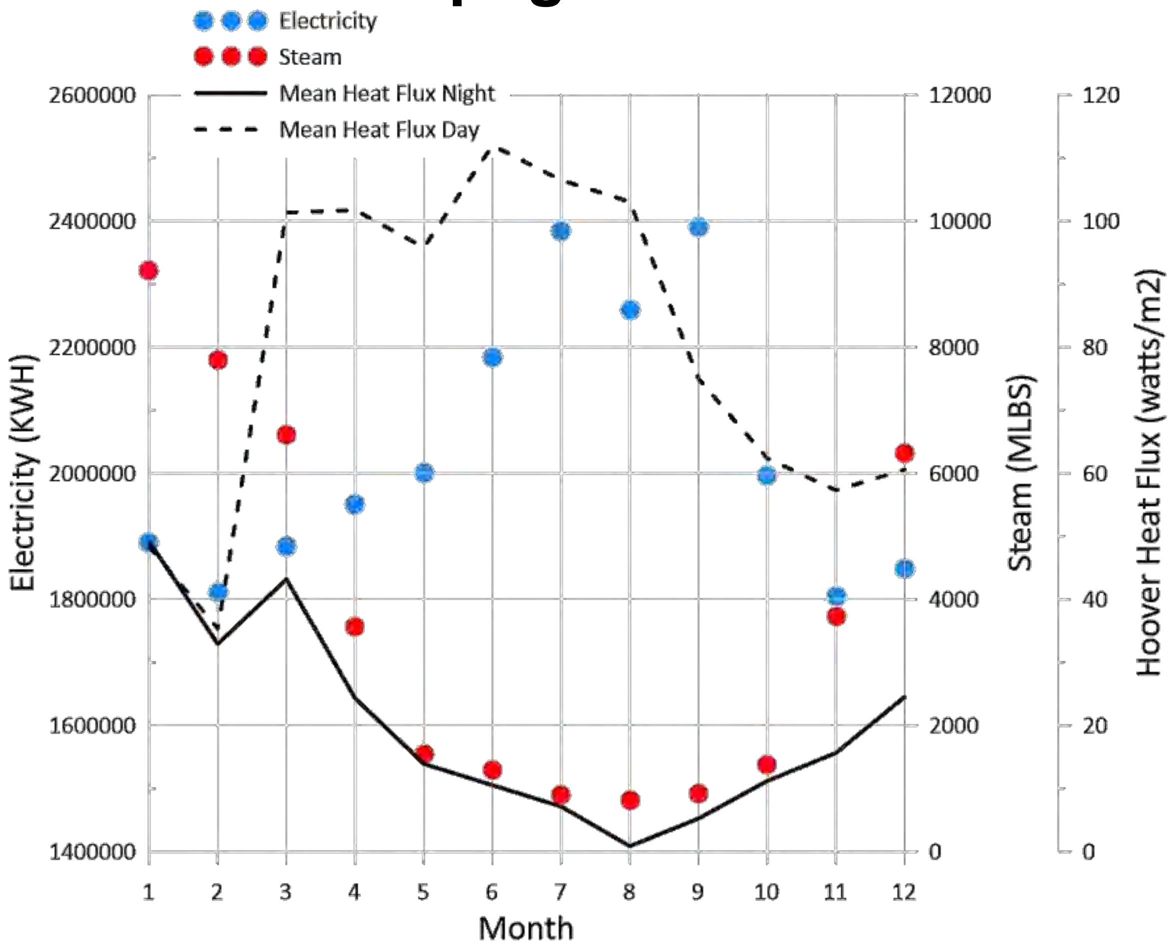
	u'²/TKE	v'²/TKE	w'²/TKE
Garratt (1992)	1.05	0.66	0.28
DCNet Hoover	1.03	0.66	0.24

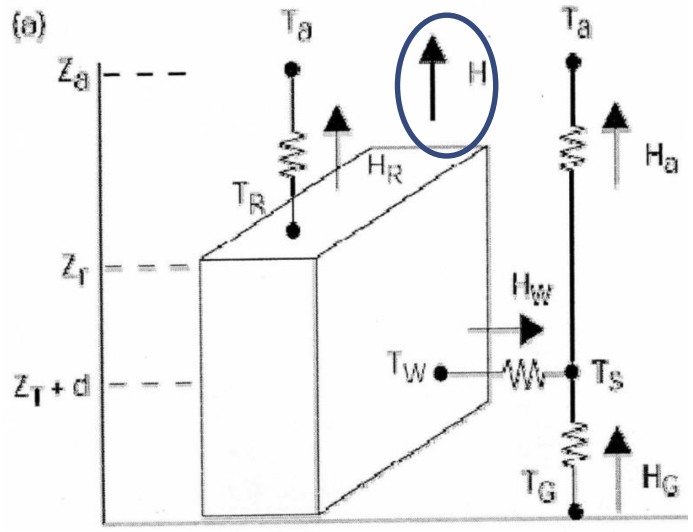
"Existing HYSPLIT TKE turbulence schemes based on Garratt (1992) appear to model the NCR turbulence environment."



Understanding Urban Heat Flux

Anthropogenic Heat Flux

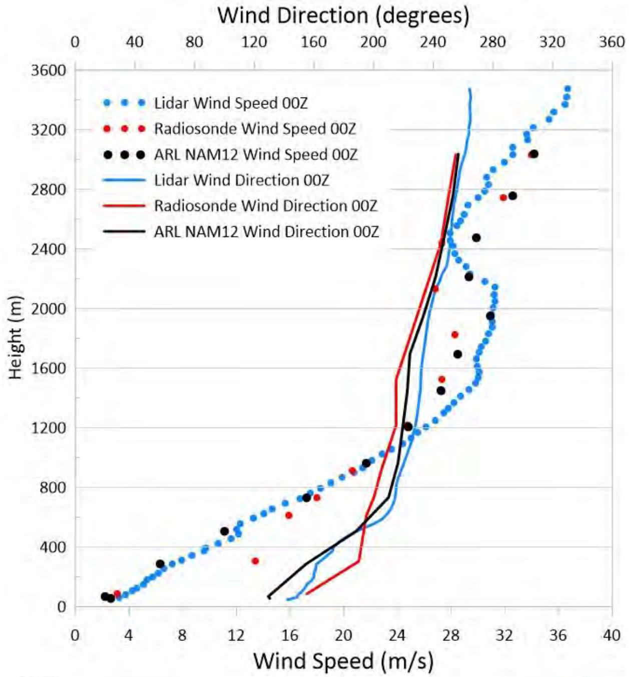


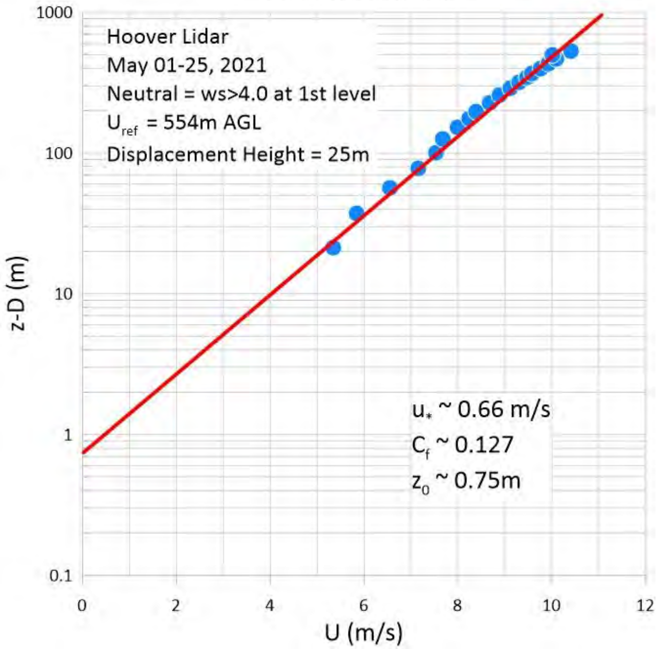


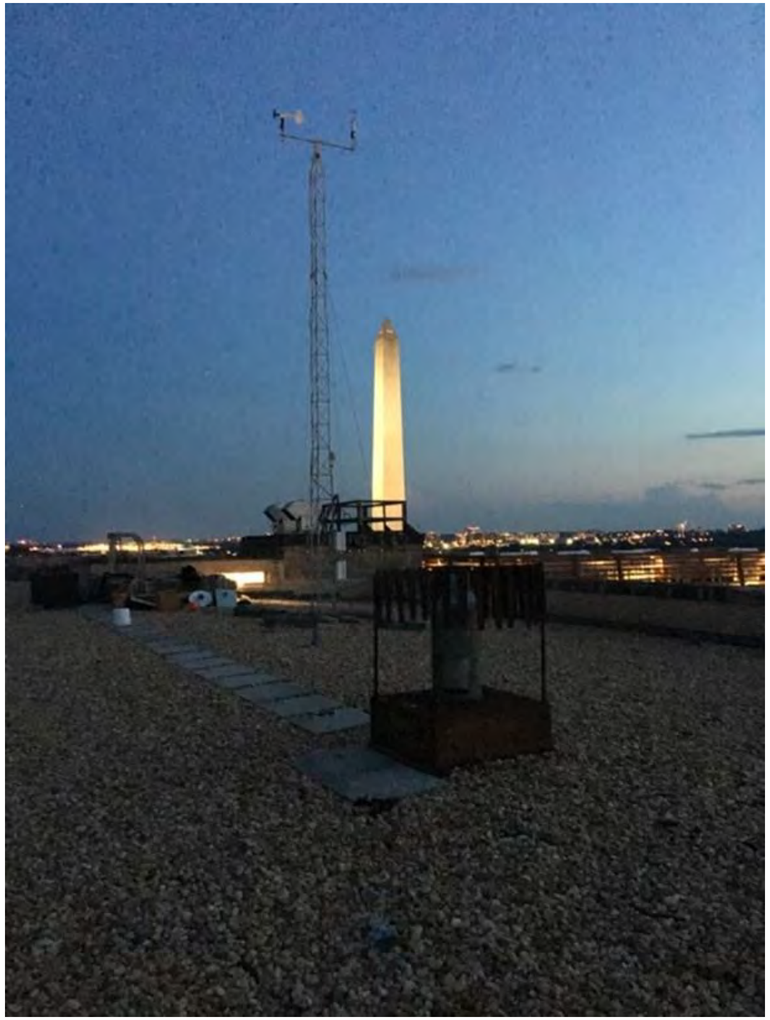
DCNet rooftop Heat flux measurements reflect a total heat flux which includes anthropogenic components

“A solution for obtaining large grid square building model inputs may lie with building energy demands – More work needed!”

Stepping Forward







DCNet Hoover Station
U_* ~ 0.681 m/s
C_f ~ 0.131
Z_0 ~ 0.503m

Collaborators

Selected Publications:

- *Temporal and Spatial Aspects of velocity Variance in the Urban Surface Roughness Layer*, B. Hicks, et al, 2013, Journal of Applied Meteorology and Climatology, Vol. 52, pp. 668-681.
- *On the Drag and Heat of Washington, D.C. and New York City*, B. Hicks et al, 2013, Journal of Applied Meteorology and Climatology, Vol. 53, pp. 1454-1470.
- *Urban Turbulence in Space and in Time*, B. Hicks et al., 2012, Journal of Applied Meteorology and Climatology, Vol. 51, PP. 205-218.
- On the Heat Islands of Washington, DC and New York City, NY, B. Hicks et al, 2010. Boundary-Layer Meteorology, Vol. 135,pp. 291-300.
- Applying Local Data to Urban Dispersion Forecasting, B. Hicks et al. 2005, Air And Waste Management Association Forum.
- Urban Dispersion for the 21ST Century, B Hicks, Safety and Security Engineering, Vol. 82, 2005, WIT Press, ISSN 1743-3509, pp.555-563.

Concluding Remarks

Urban Core Morphology		
Parameter	0.25 km^2 Mean	1.00 km^2 Mean
Mean Building Height	25.05	17.01
Building Height StdDev	8.57	9.46
λ_P	0.33	0.30
λ_B	1.51	0.91
λ_F 0	0.29	0.16
λ_F 45	0.42	0.22
λ_F 90	0.29	0.15
λ_F 135	0.41	0.22
λ_S	0.58	0.35

Location	Land Use Class	λ_p (0.25km)
Los Angeles, USA	Down Core	0.29
Vancouver, BC	Downtown	0.37
Mexico City, Mexico	Downtown	0.47
National Capital Region	Downtown	0.33

- DCNet observations have established the near-neutral skimming flow for the National Capital Region.
- Promising work towards regional heat flux input by linking measured heat flux and building energy demands.
- Obvious transfer of DCNet experience to other urban areas through plan or frontal areas.
- Opportunity exist with co-located wind lidar.
- Focus on core DC Federal Triangle.