Validation Results of a Spatially Fine-Scale Air Temperature Statistical Model in New York City

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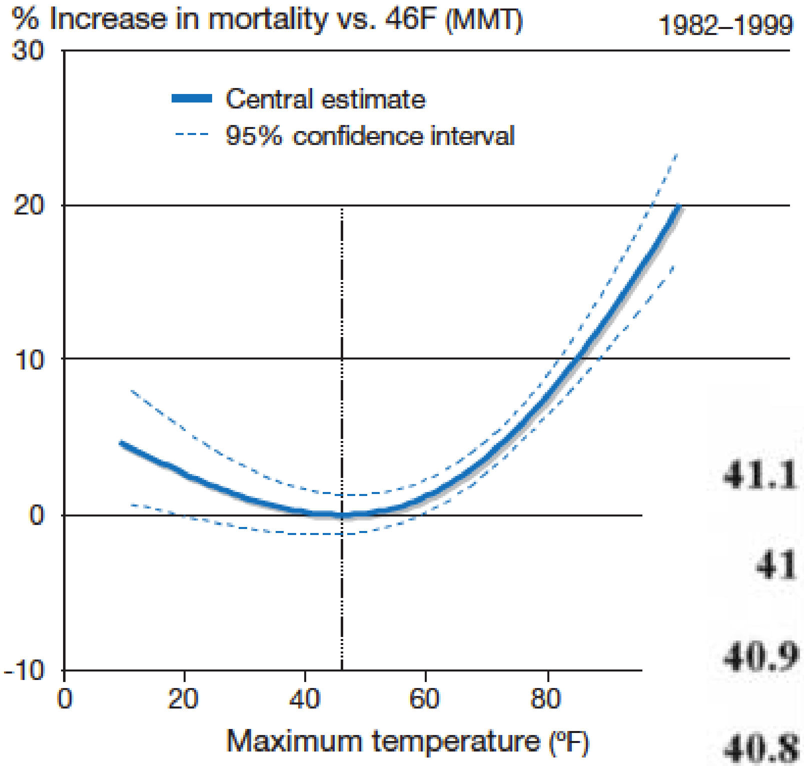
Outline

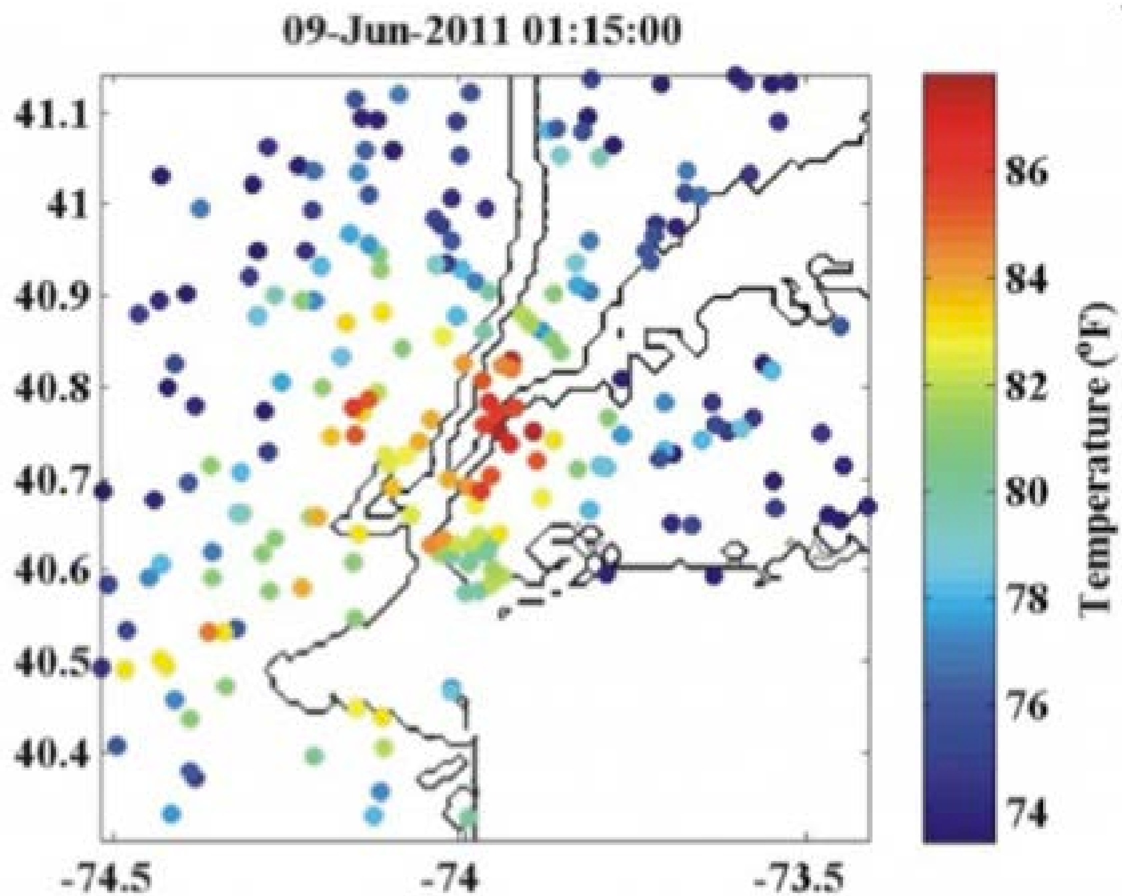
- Motivations for project
- Data set (summers 2012-13)
- Statistical Model (Fall 2014)
- Evaluation

Urban Temperatures and Mortality



Patrick Kinney, NYC ClimAID Report 2013

NYC MetNet data



from "Forecasting the New York City urban heat island and sea breeze during extreme heat events". Meir, Orton, Pullen, Holt, Thompson and Arend in *Weather and Forecasting, 2013*

Project Goal

Create a High Resolution Statistical Model to predict (current or 1 day forecast) inner city temperature variations using data sets and computational techniques easily accessible to the Health Community.


3.5 M
1.5 M

Field Campaigns

Temps, RH => dewpoint

High spatial resolution measurements:

2 pm, ~ 40 minutes, 1.5 m AGL

- 19 Simultaneous street walks (mainly in shade)
- 13 Simultaneous avenue walks (mainly in sun)
- Every 10 seconds, averaged to ~ 2 minutes; ~ 150 m

High time resolution measurements:

- Fixed Instruments, 10 locations
- 3 minute increments, 3 months
- ~ 3.5 m agl

Color Scheme for all Measurement Units

Black	< -1.75 units
Blue	-1.25 to -1.75 units
Light blue	-0.75 to -1.25 units
Green	-0.25 to -0.75 units
Yellow	+/- 0.25 units; average
Orange	+0.25 to +0.75 units
Red	+0.75 to +1.25 units
Purple	+1.25 to +1.75 units
White	> + 1.75 units

Bluer is lower: Yellow is Average: Redder is higher

Temp Avgs

< In the shaded street data, low buildings are warmer, vegetation and higher elevations are cooler.

Student T-test values > Purple or dark blue is significant at 90% confidence level

Bluer is lower: Yellow is Average: Redder is higher

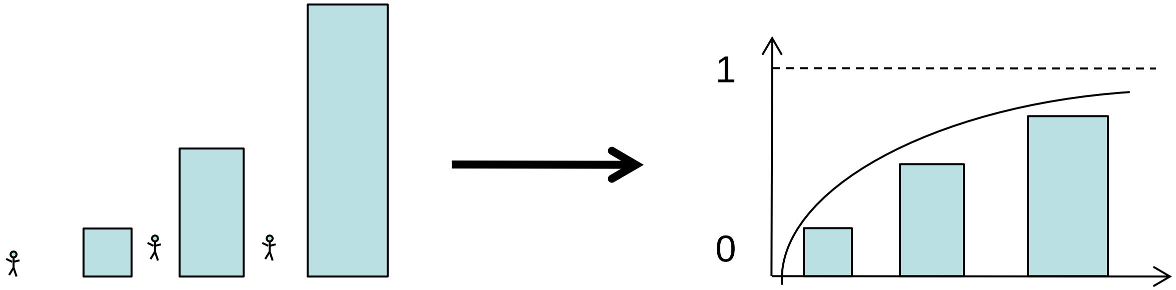
Surface Data Sets

USGS survey - 30 m resolution
- elevation
- water (elevation < 0.15 m)
- 1km^2 water fraction

LandSat - 30 m resolution (processed by undergrad
- Vegetation (NDVI)
- Albedo (narrow to broadband conversion)

NYC mapPluto - aggregated to 100 m resolution
- Building height
- Building area fraction

Variable Modifications

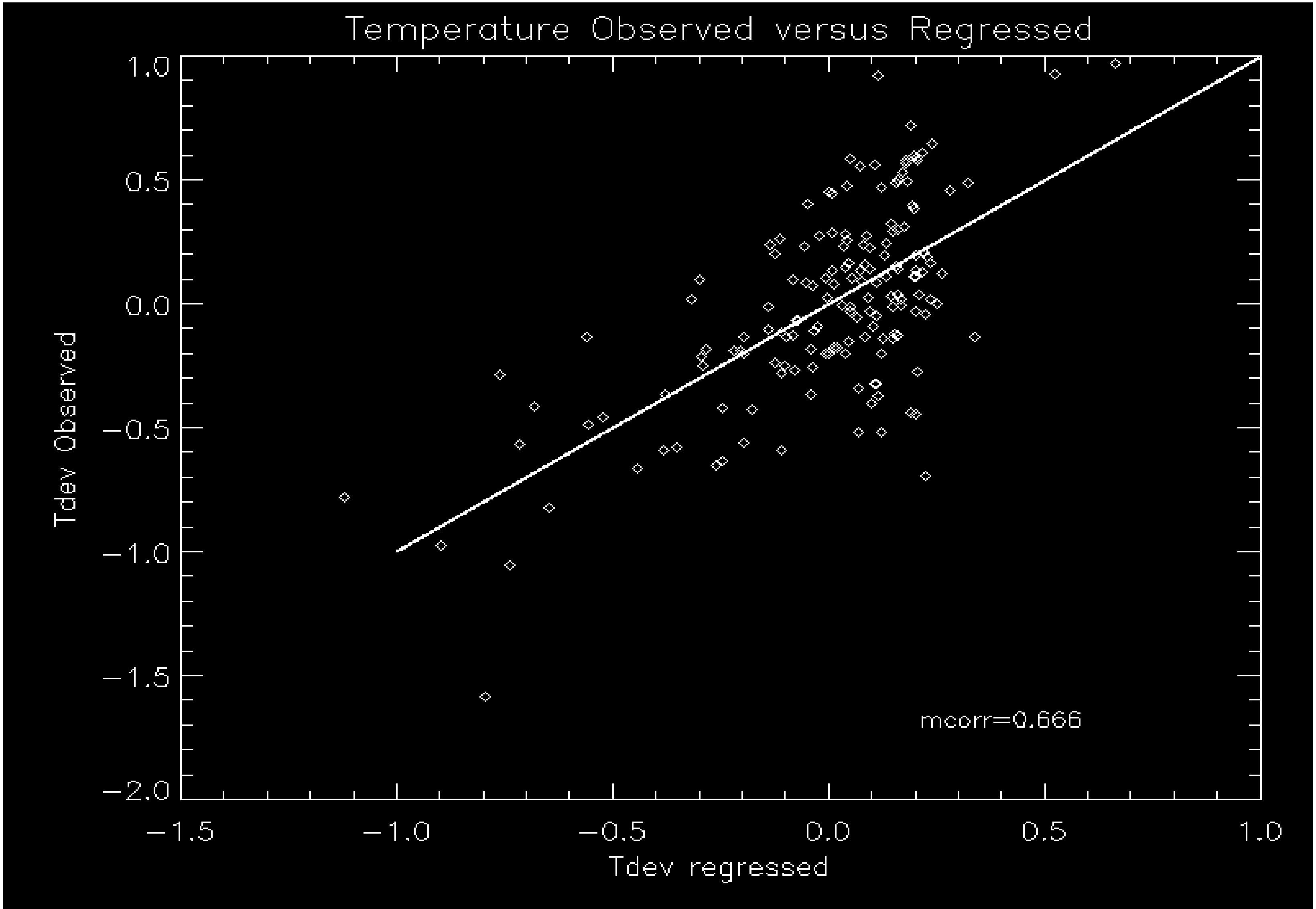


Scaled Building Height => 1 - exp(-H/Ho)
Ho = 7.5 m *(0 < SBH < 1)*

Scaled Building Volume = SBH x Building Area Fraction

note that 1 - SBV ~= Sky View Fraction

Regression of local Temperature Anomalies to Surface Characteristics



Correlations and Coefficients

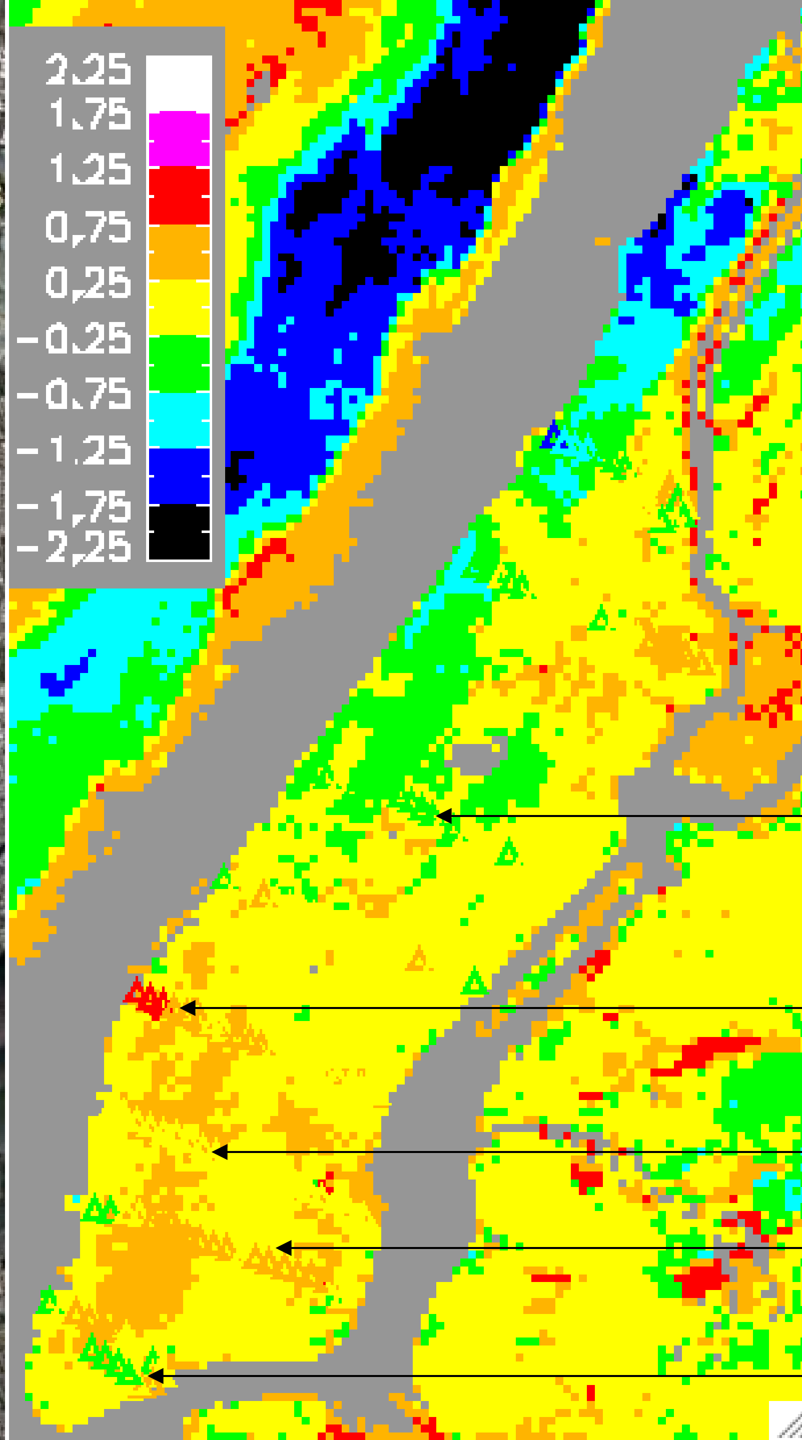
Temperature anomalies to Surface Variables

Trustworthy *Important*

0 to 1

Variable	Correlation	Coefficient
Elevation	*Trustworthy*	*Important*
NDVI	- 0.39	- 0.59
Build Volume	0.087	2.5
Build Area %	0.08	- 2.1
Albedo	0.06	- 0.70
Water %	0.02	- 0.81
Build Height	- 0.01	- 0.76

1 std dev ~ 1 degree C



When observations differ from the model predictions

Cool in the Park

Hot spot at piers

Unpredicted average

Warm in villages

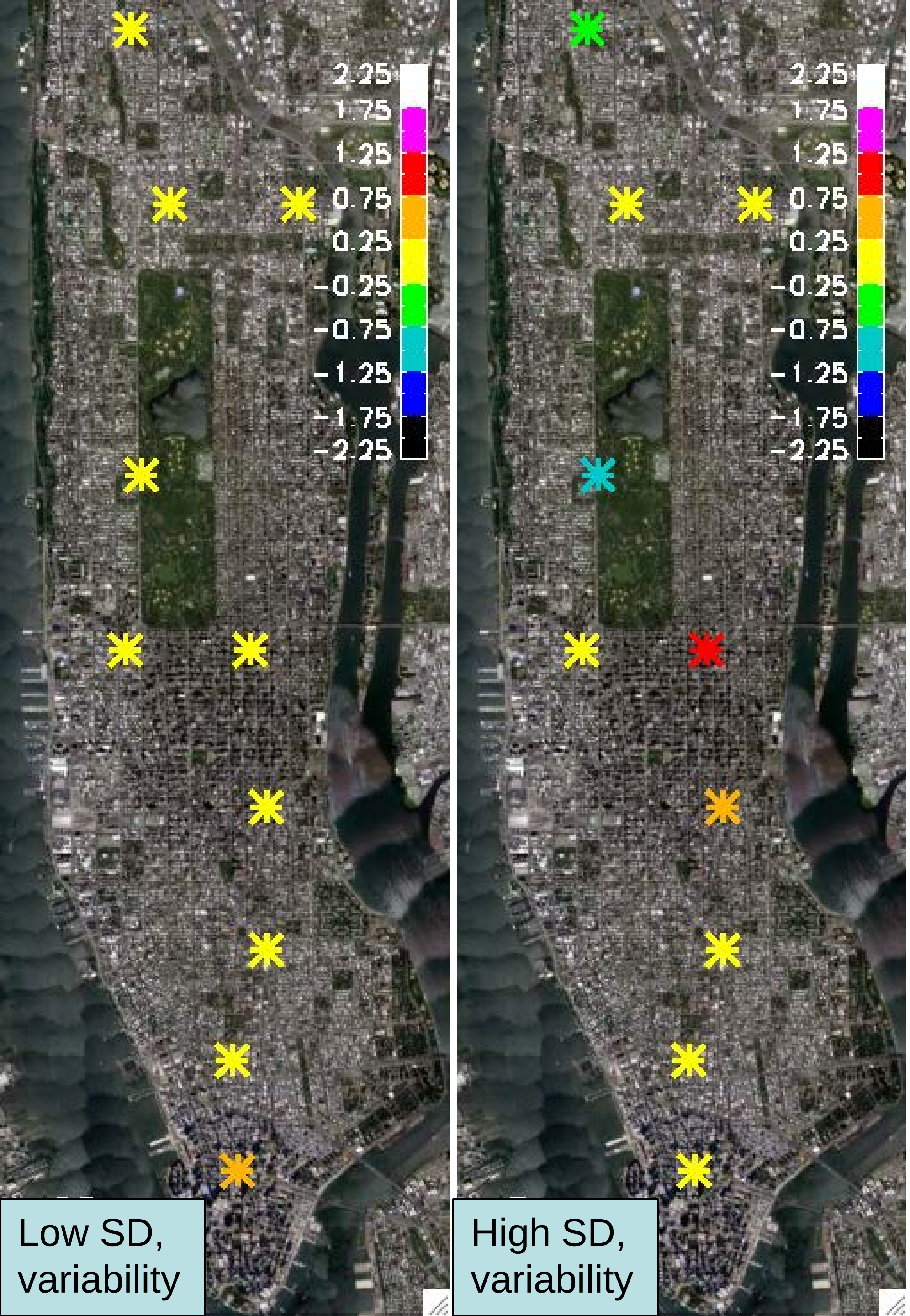
Cool in downtown

Temperature Difference between Highest and Lowest Elevation Stations

(Work done by Maryam Karimi)

Variable	**Correlation**	**Coefficient**
Temp	0.471	0.067
RH	-0.134	0.011
Northward Wind	0.186	0.012
Eastward Wind	0.278	0.025
CF	-0.047	-0.003
Mid Level LR	-0.106	-15.315
Low Level LR	-0.216	-41.859
V Total	0.018	-0.001
Evaporation Rate	0.076	0.024

Temperature (sunlight?) and wind more important than the change of air temperature with altitude (lapse rate)



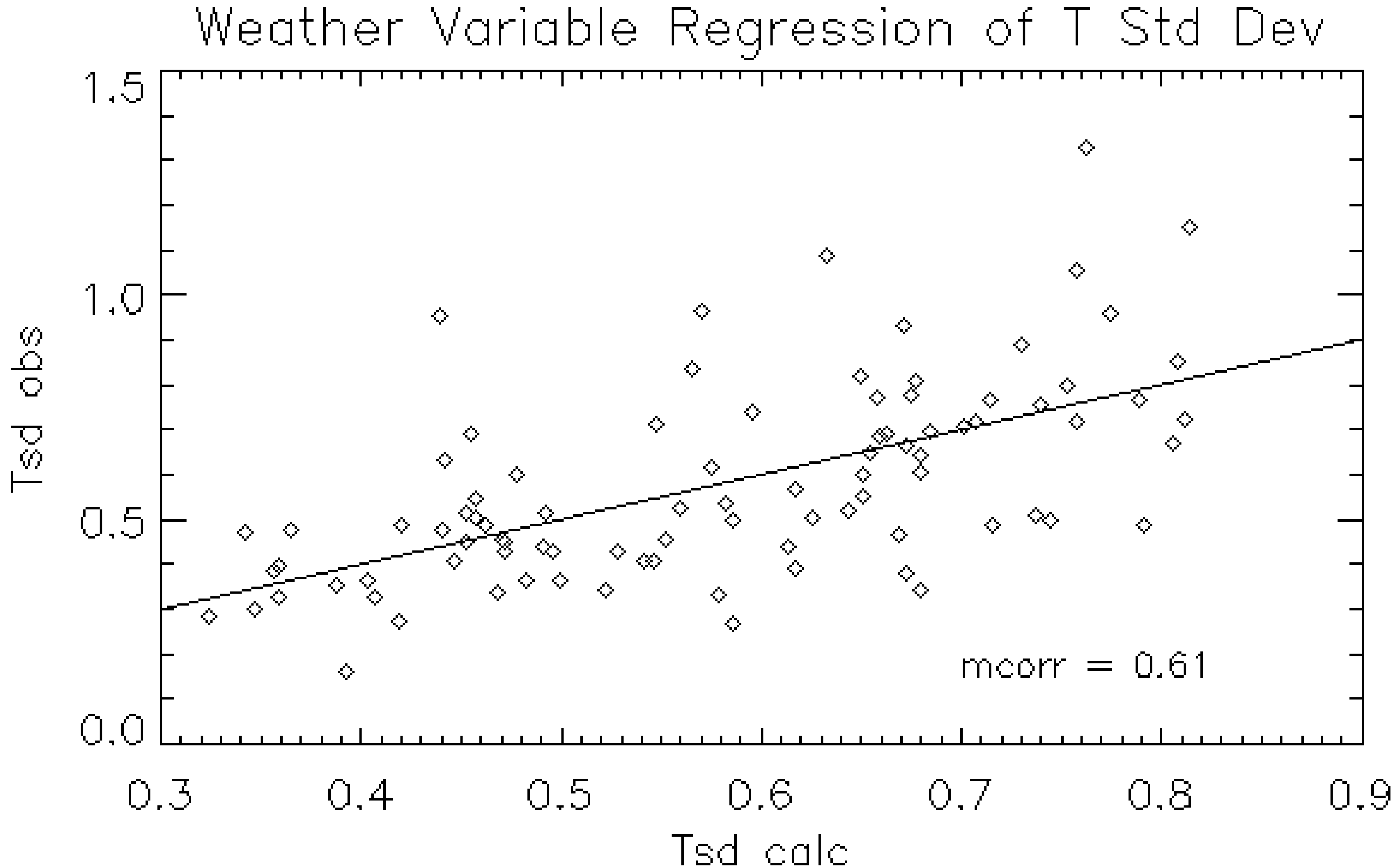
During 3 months the fixed instruments sample a wide range of meteorological conditions, reflected in the spread of temperatures between locations. The standard deviation is a measure of spatial variability.

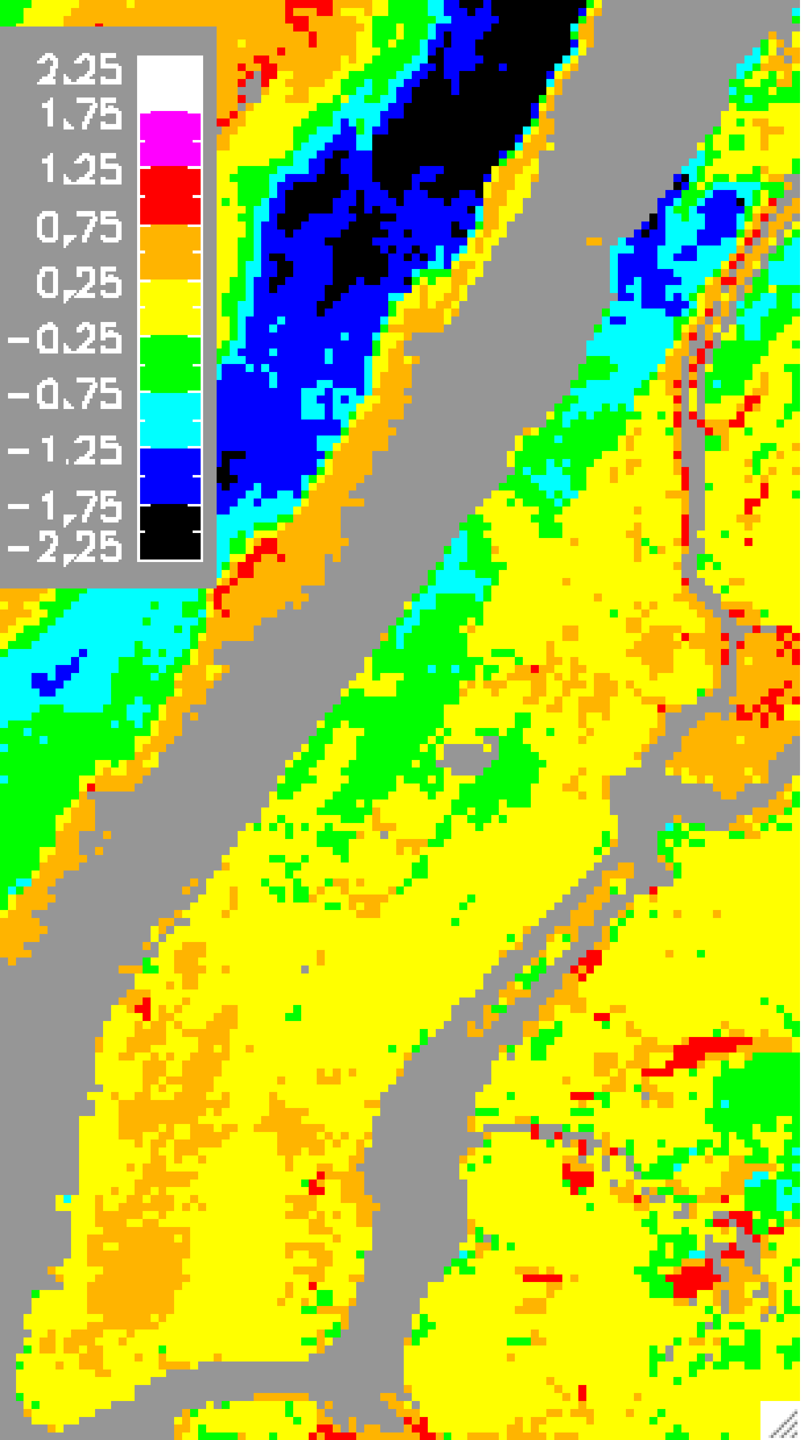
Since our field campaigns are scaled to standard deviation, we can relate weather to the amplitude of temperature variation within the city.

(3.5 m agl)

Weather and Temperature Anomaly Amplitudes

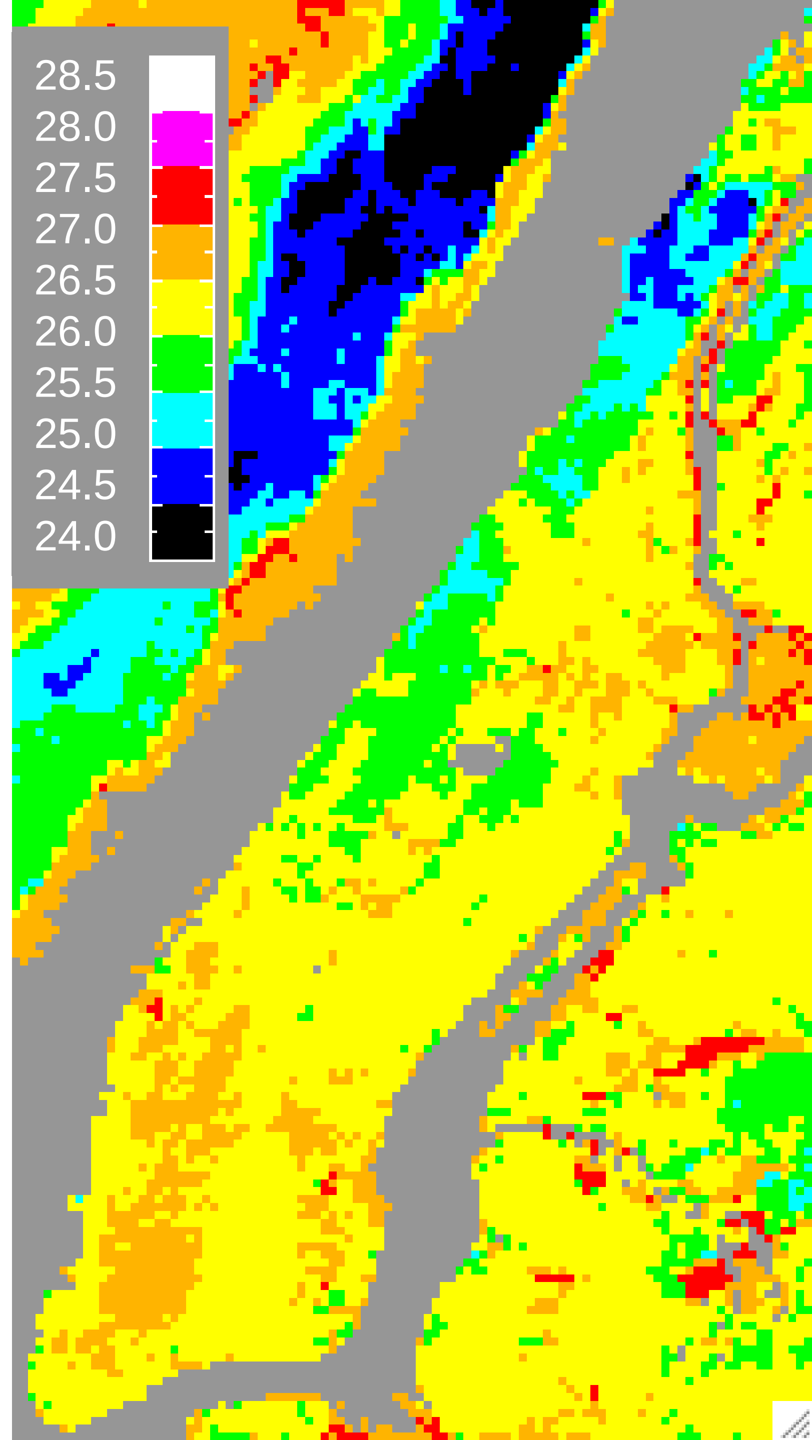
A windy overcast day is expected to have different temperature variations within the city compared to a calm clear day.





Actual degrees

Weather forecast



Critique: is the anomaly function Separable?

Temperature Anomalies = F(surface, weather)

?= G(surface) * K(weather)

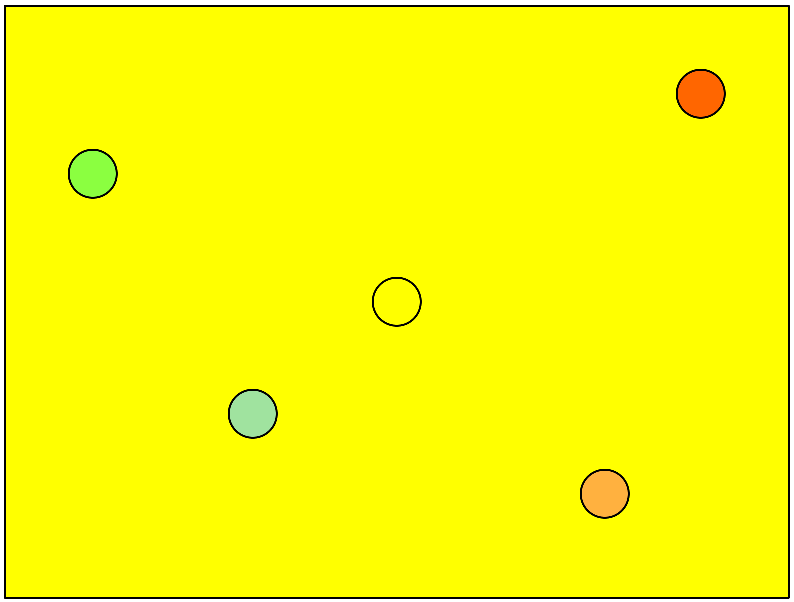
(Anomaly map * Amplitude)

Not rigorous; and yet…

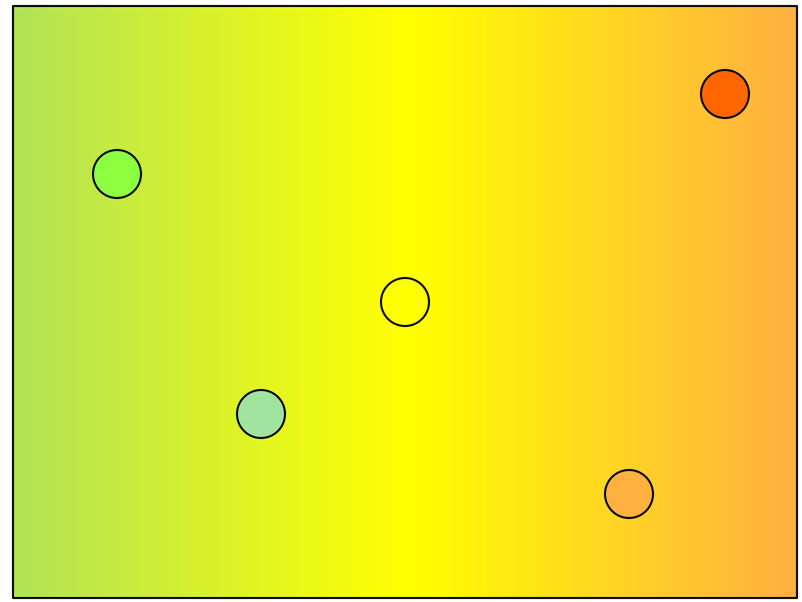
…simple approximate tools get more use.

Comparing Spatially Uniform T vs Model T

Uniform T forecast



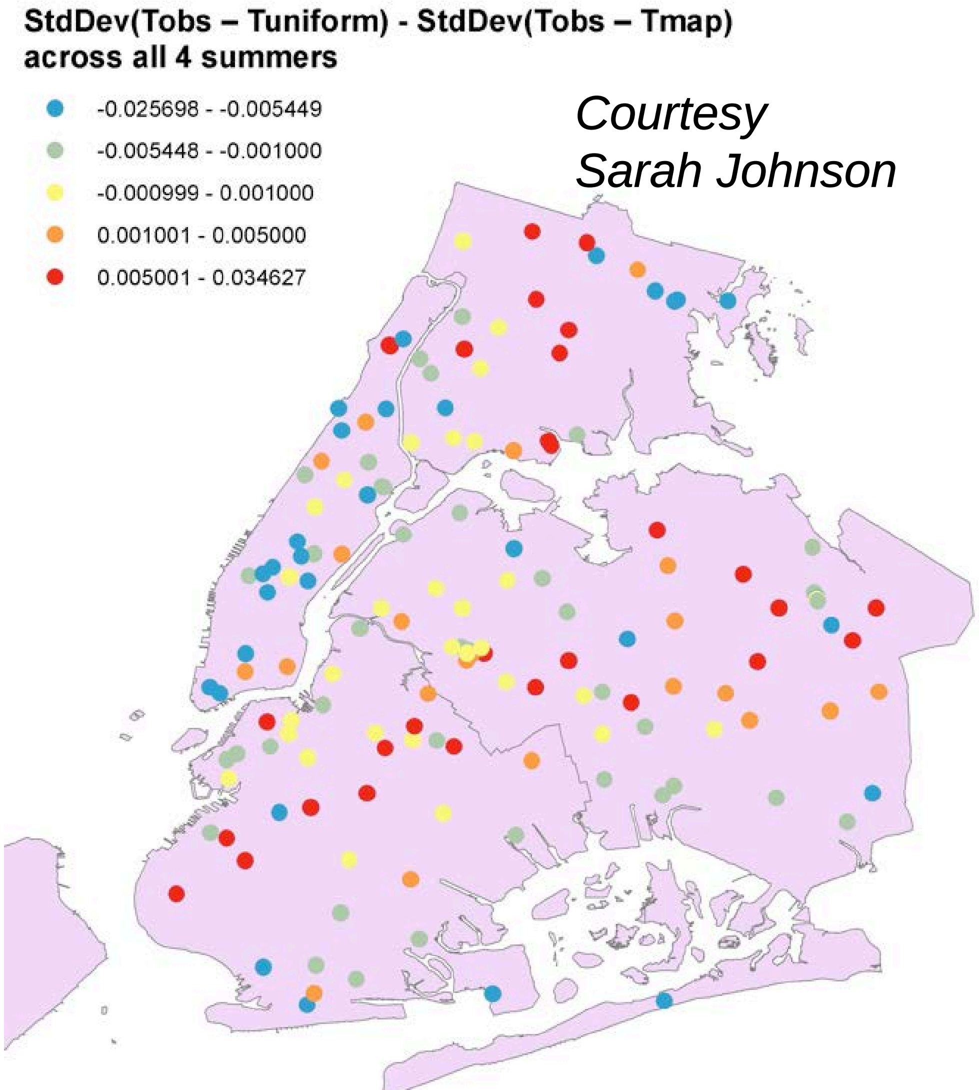
Modelled T forecast



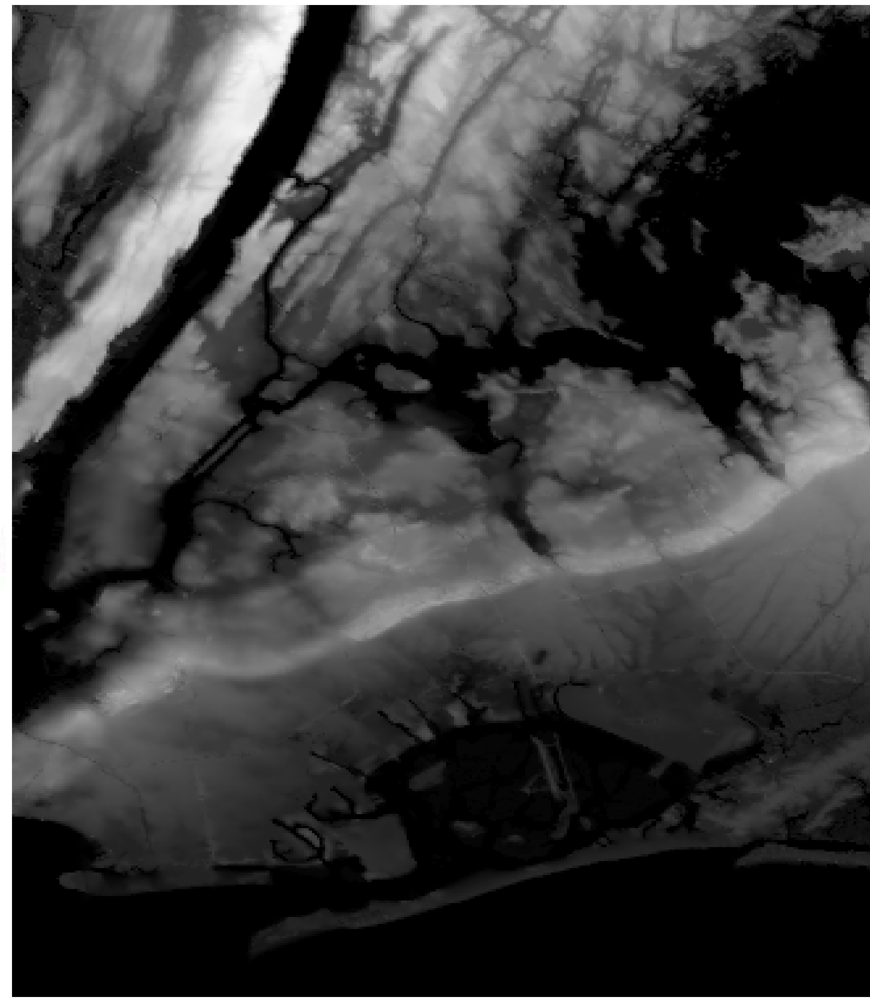
$$\mathrm{StdDev}(T_{observed} - T_{uniform}) > \mathrm{StdDev}(T_{observed} - T_{model})$$

3 months of observations with our 10 stations on Manhattan
calculating spatial variability each day (Tsd ~ 0.6 C)
show an average reduction of 8% in standard deviation.
(work done by High School student Louis Waxman)

Department of Health Comparison: Variations at each point through time



Courtesy Sarah Johnson



elevation

NOTE: net yet controlled for sun/shade

Summary

- The temperature anomaly ***pattern*** was regressed against surface characteristics: buildings, vegetation, and elevation.
- Anomaly ***amplitudes*** are predicted via regression of weather variables.
- Higher elevations match the model best, most likely due to wind effects.
- Differences between observed and predicted temperatures are slightly improved over a uniform temperature field. The weak performance may be due to over-fitting, the assumption that surface and weather contributions are separable, or weak correlations used in combination.

http://glasslab.engr.ccny.cuny.edu/u/brianvh/UHI

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