MODELING URBAN AREAS AND SUPERCELLS IN WRF

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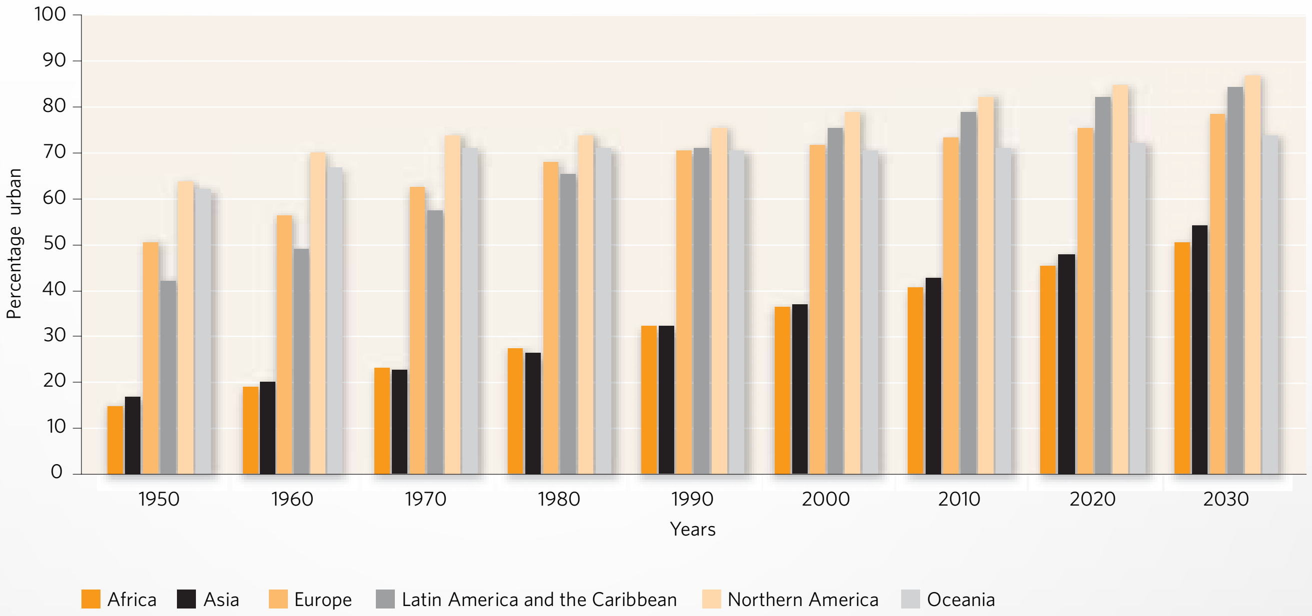
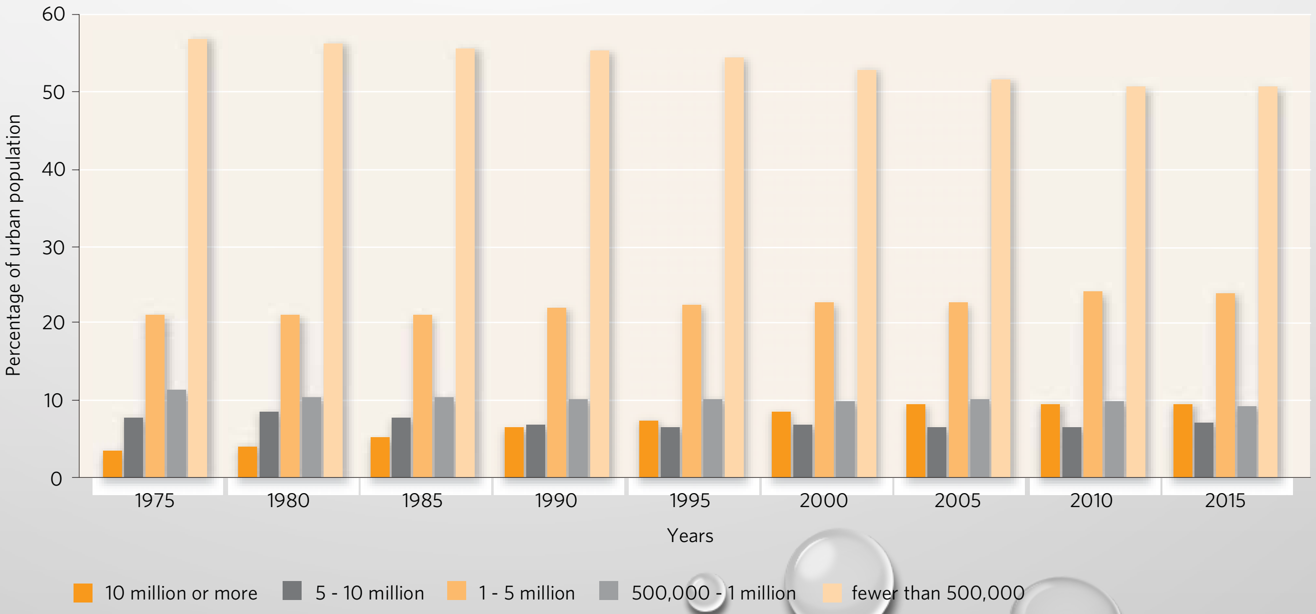
Percentage of population at mid-year residing in urban areas, by region, 1950-2030



Source: United Nations. 2006. *World Urbanization Prospects: The 2005 Revision*, Table A.2. New York: Population Division, Department of Economic and Social Affairs, United Nations.

Urban Population, by Size Class of Settlement, World, 1975-2015

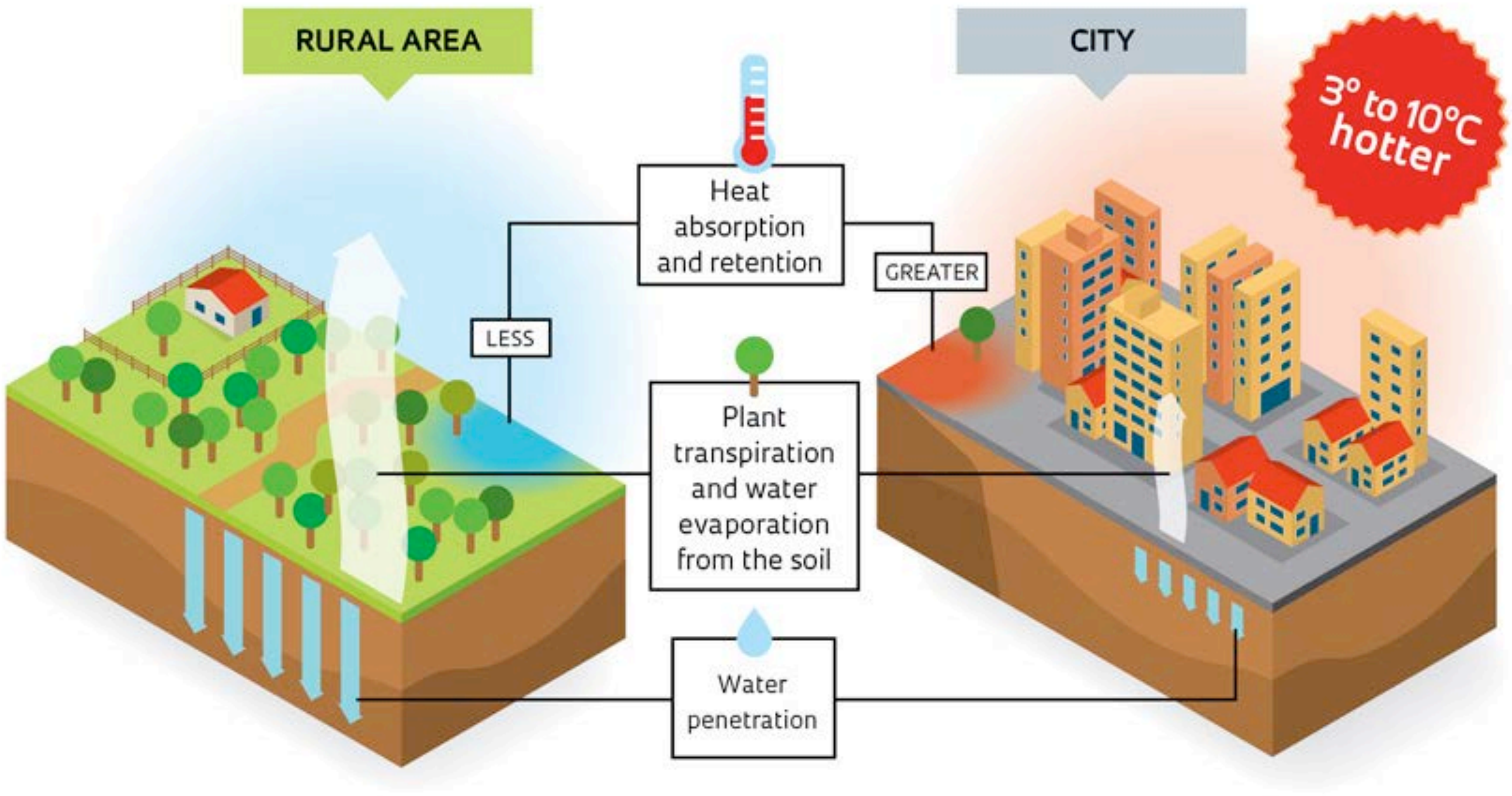


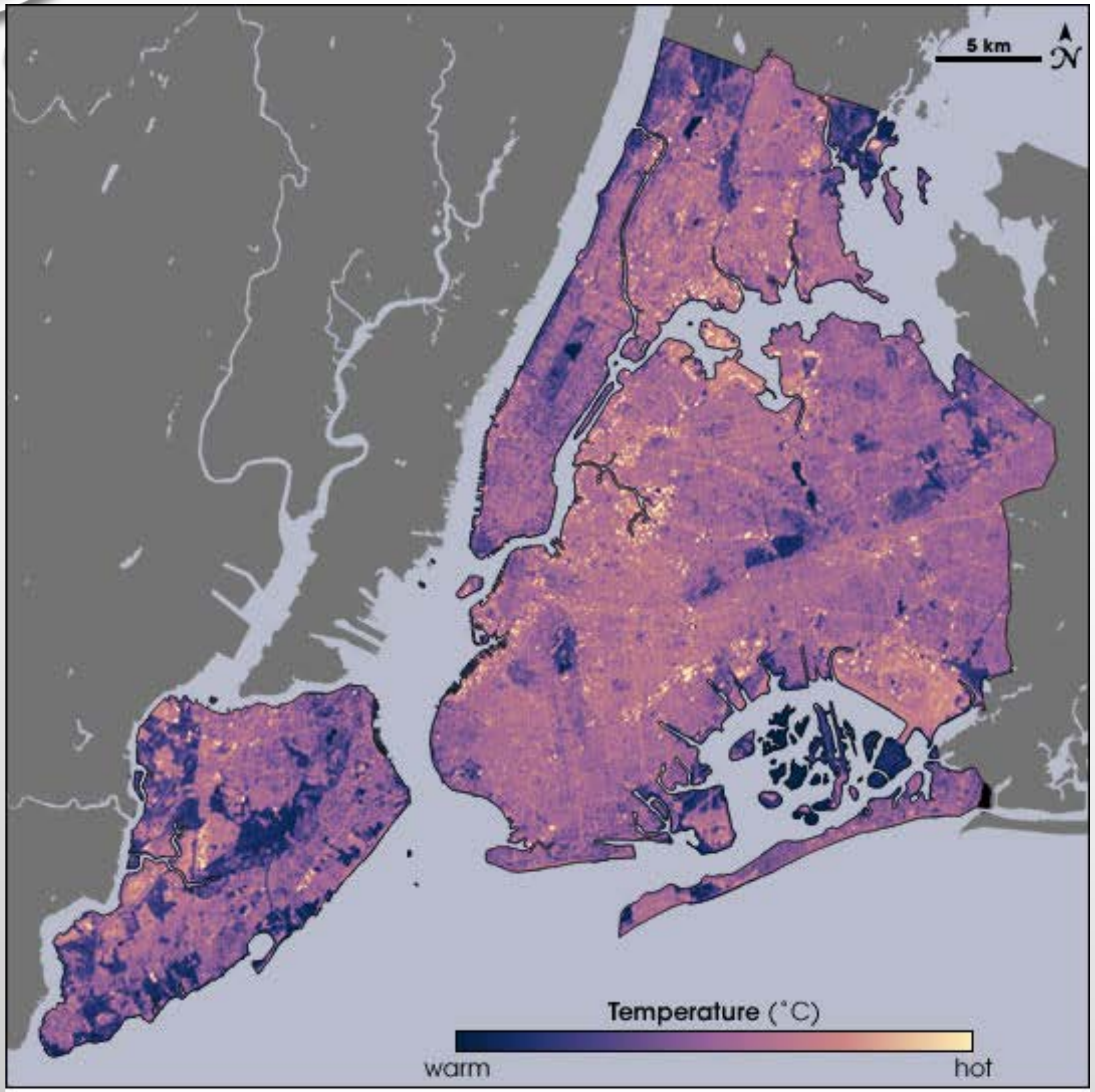
Source: United Nations. 2006. *World Urbanization Prospects: The 2005 Revision*, Table A.17. New York: Population Division, Department of Economic and Social Affairs, United Nations.

Missouri, disastersafety.org

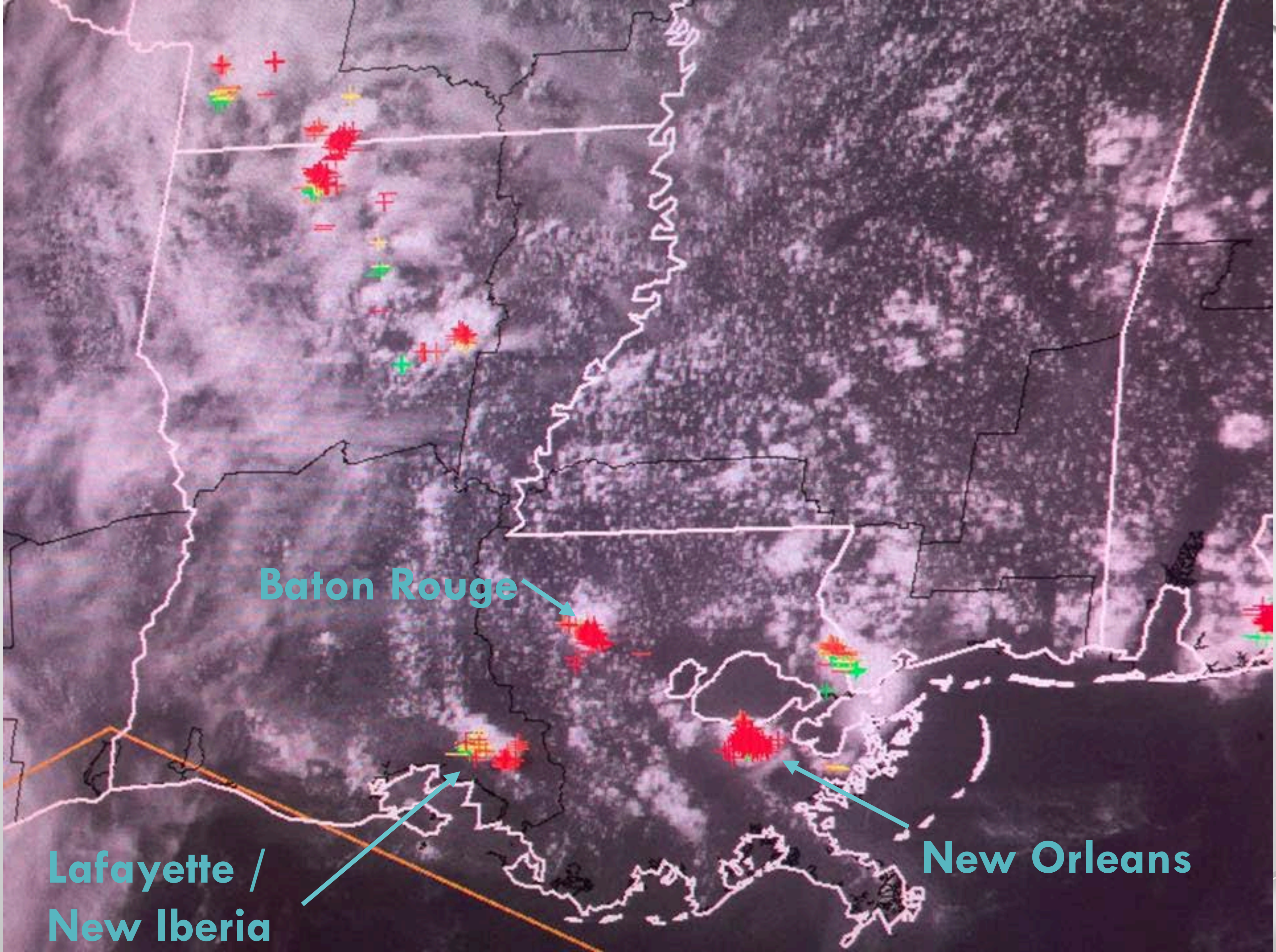
Joplin, AP

Why the urban heat island effect occurs





Replacement of vegetation with urban areas → urban heat island (UHI)


Baton Rouge
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New Orleans


Hail Storm Products – The Hail Protector® external car airbags


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Nathan Weber, TIME

BROAD RESEARCH QUESTIONS

1. How does the change in land use/ land cover of a city affect the pre-storm environment?
2. Do cities affect the storm?
3. How does changing a city's location relative to the path and storm life cycle change that affect?
4. How do these affects change with cities of different size/shape?
5. What results in the most change, dynamic or thermodynamic effects?

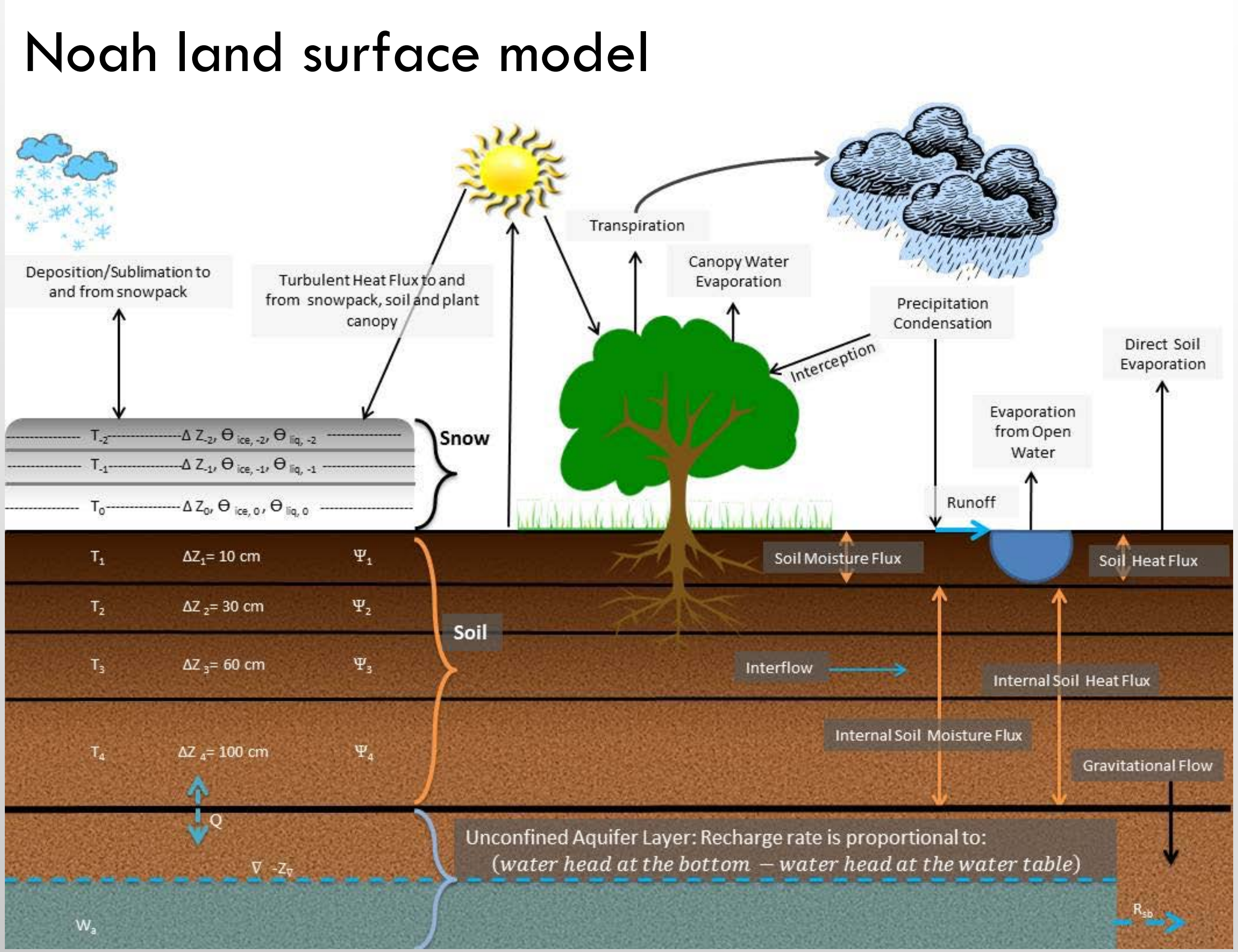
PART 1: MODELING AN URBAN AREA

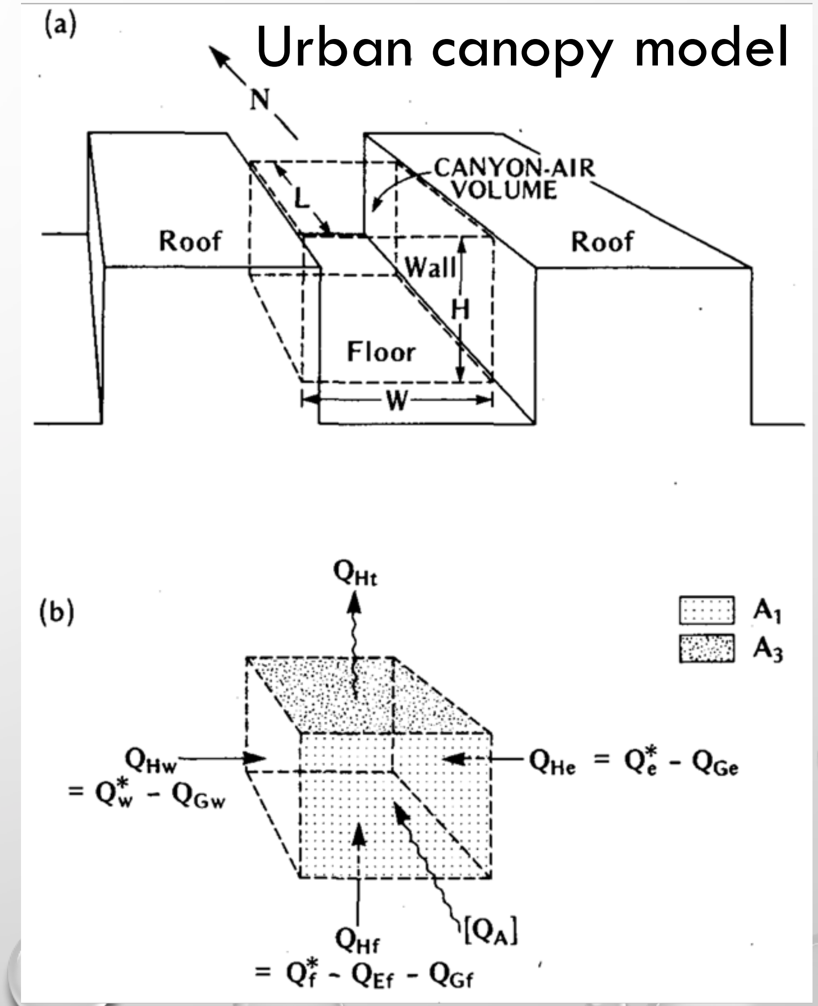
Main question: How should great plains cities be represented in the WRF?

WEATHER RESEARCH AND FORECASTING MODEL (WRF)

- Community mesoscale numerical weather prediction model
- Easily scaled for large problems, large systems
- Fully compressible , non-hydrostatic
- Parameterized:
  - Short and long-wave radiation
  - Surface and sub-surface heat and moisture fluxes based on surface properties
  - Turbulence in the atmospheric boundary
  - Cloud microphysical properties (i.e. rain, snow, hail, etc.)

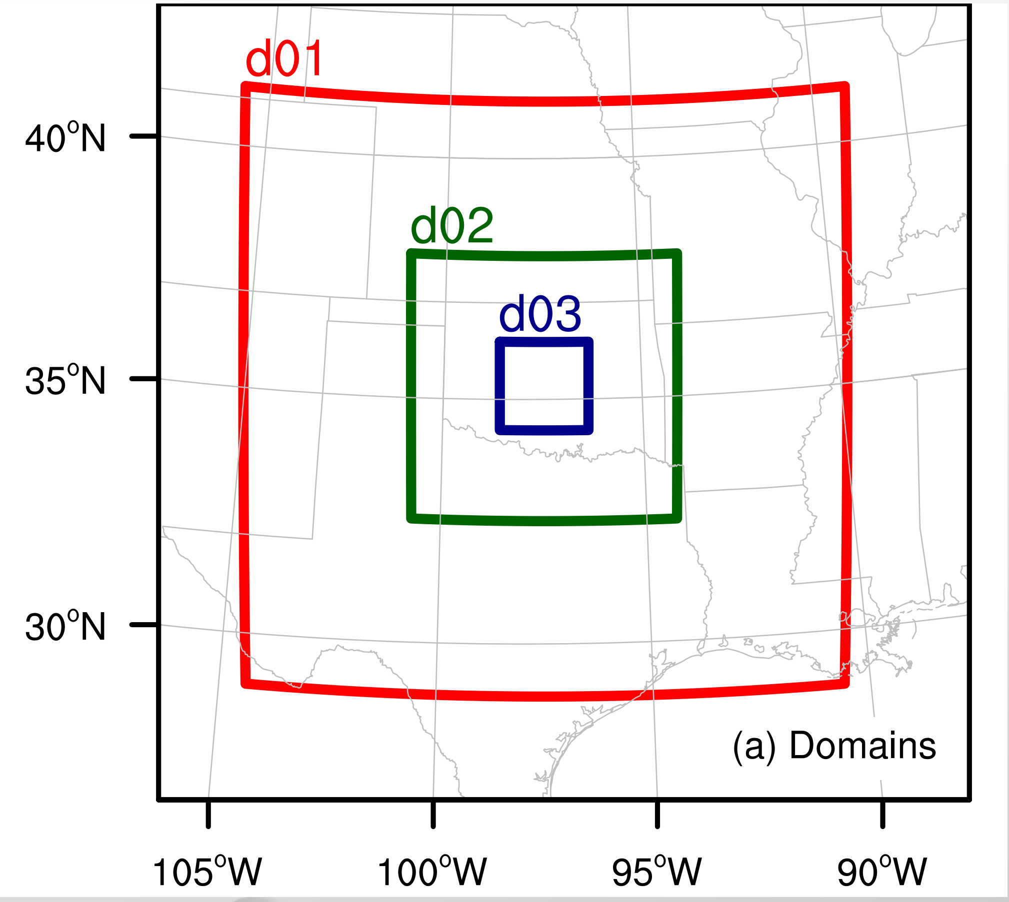
PARAMETERIZATION OF URBAN AREAS





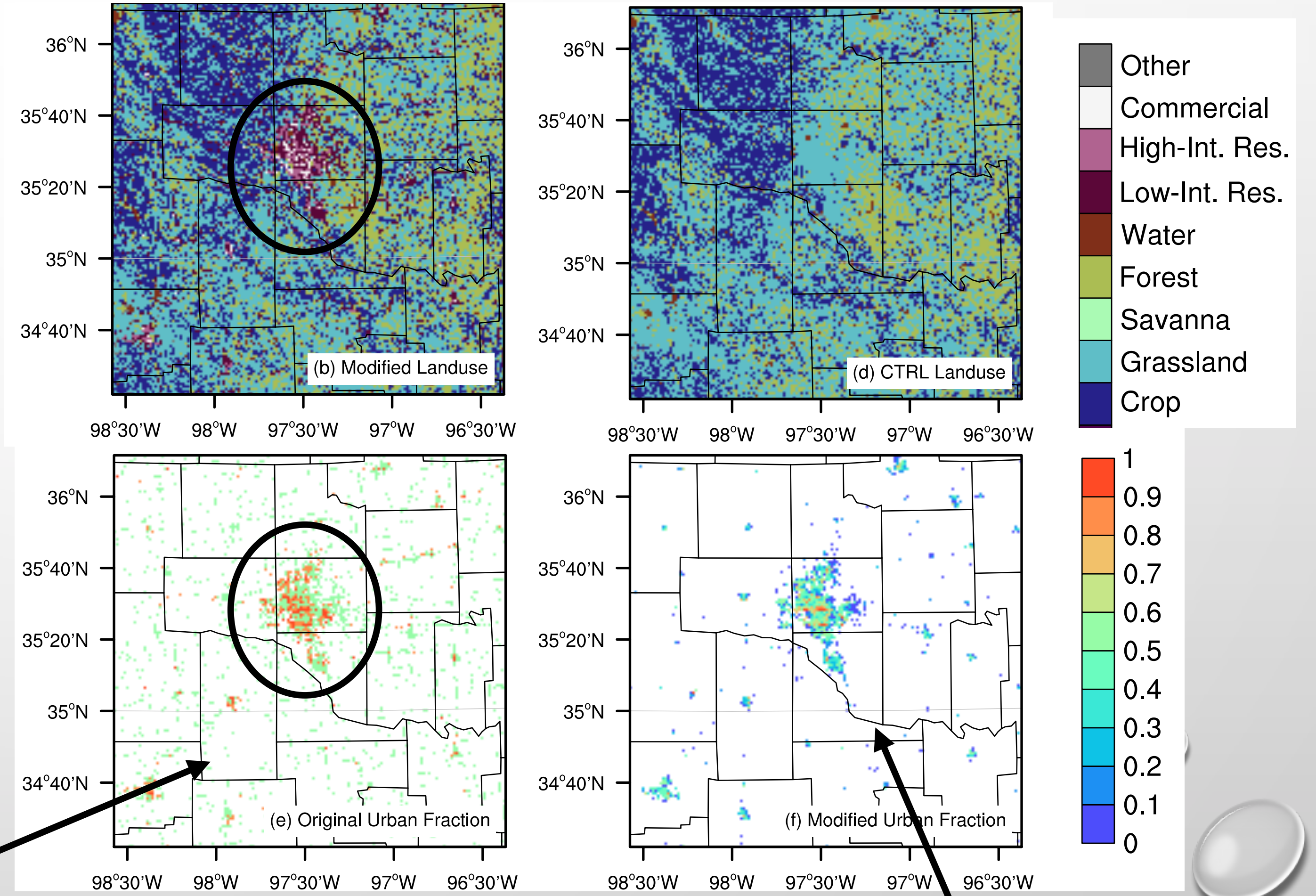
MODEL SETUP

- 2010 May 01 0000 UTC – May 08 0000 UTC
- ICs and BCs provided by RUC
- Parameterizations:
  - NASA Goddard SW / LW
  - Noah LSM + SLUCM (in SLUCM1 & SLUCM2)
  - MM5 Surface Layer
  - YSU PBL
  - NSSL Microphysics
- Domains:
  - d01: 300 x 300 x 120; 4500 m horiz. Grid; 6 s time step
  - d02 : 400 x 400 x 120; 1500 m horiz. grid; 2 s time step
  - d03 : 399 x 399 x 120; 500 m horiz. grid; 2 s time step



SIMULATIONS

- d01 & d02 run once
- d03
  - 4 final runs : CTRL, LSM, SLUCM1, and SLUCM2
  - 5-10 test runs of LSM; changed some parameters of urban area each time to get results to match observations



Model-derived

Observations

**** more accurate ****

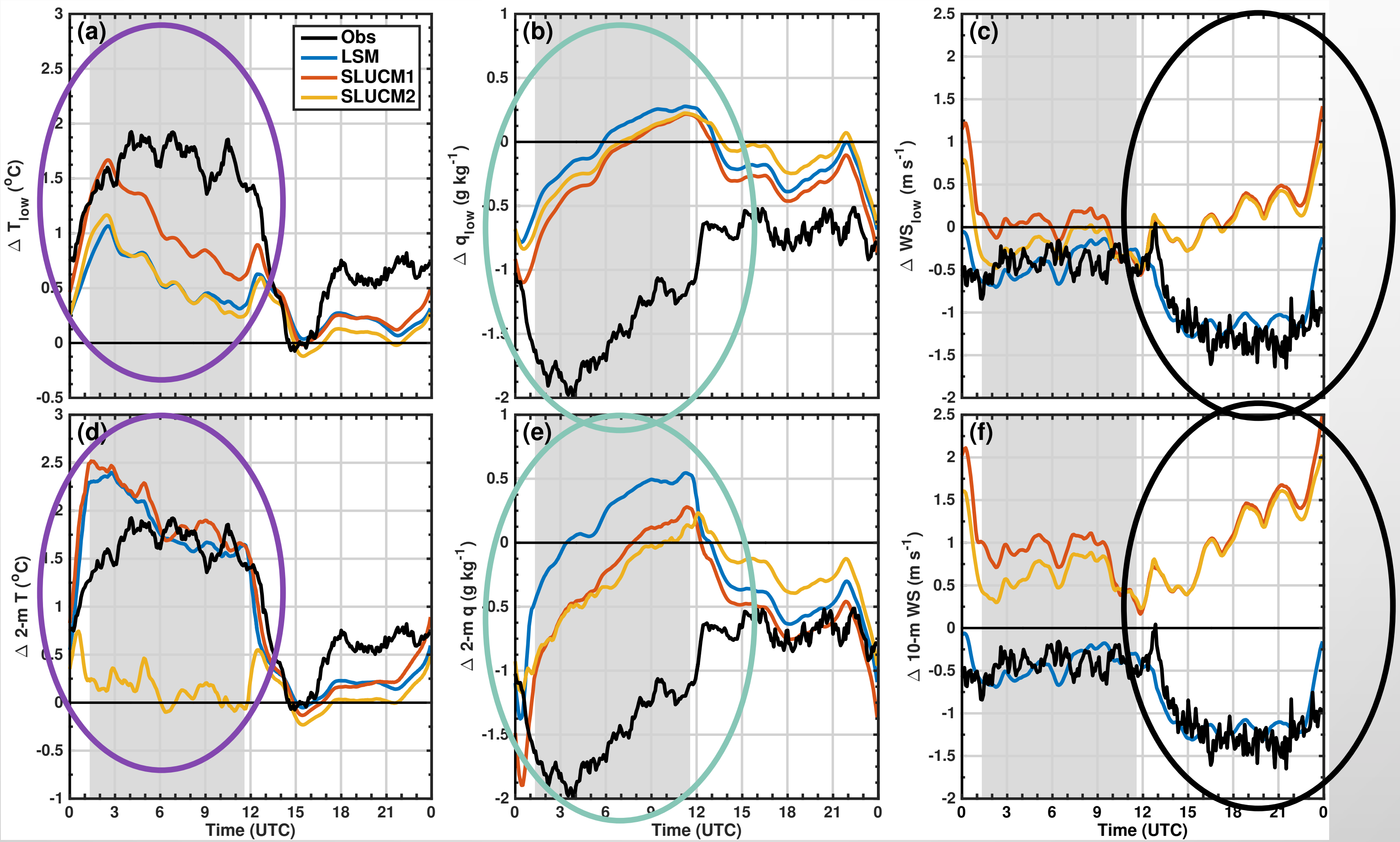
BLUE WATERS PERFORMANCE

- Each d03 run:
  - 302,400 time steps
  - > 19 million grid points
  - 15 nodes, 32 processes each
  - 1 WRF "tile" per process (domain decomposition)
- Timing:
  - ~1.44 s per time step SLUCM runs
  - ~1.28 s per time step LSM

RESULTS

First model level

Parameterized heights



ΔT Δq ΔWS

CONCLUSIONS

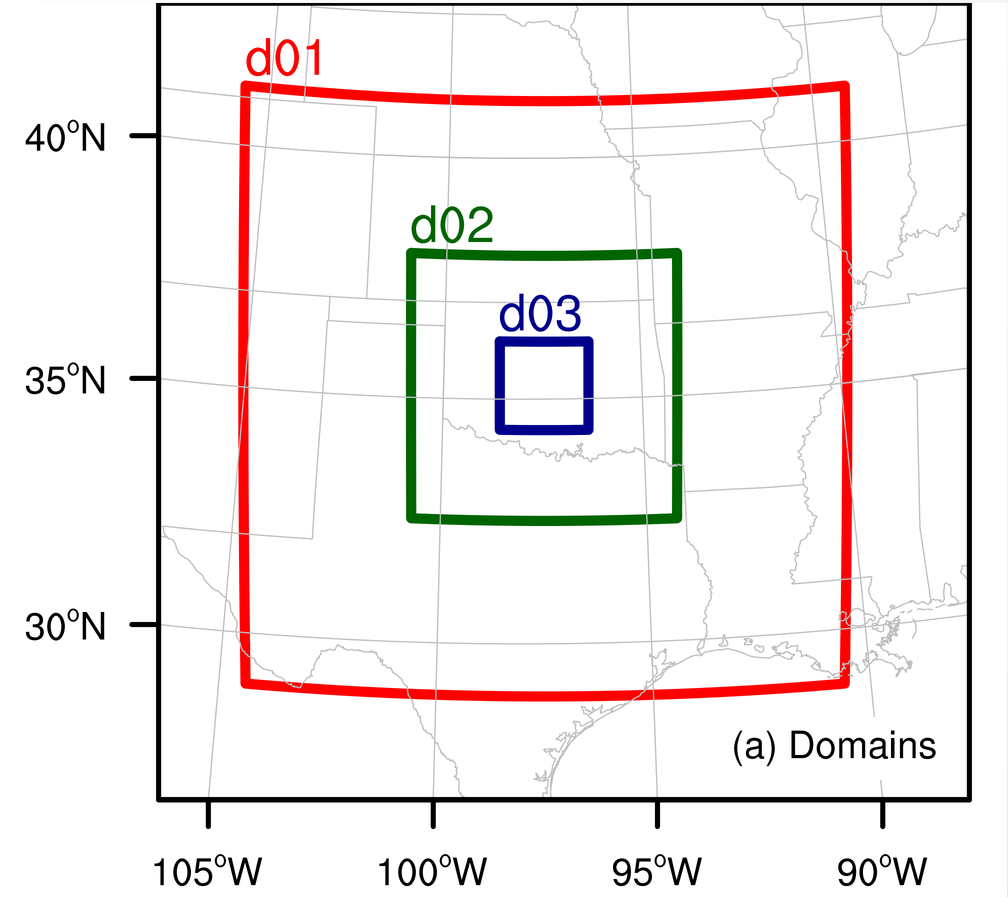
- More accurate urban data → Less-realistic nocturnal UHI in SLUCM
- Too-high SLUCM winds
- **So: Use LSM for supercell runs**

PART II: SUPERCELL RUNS

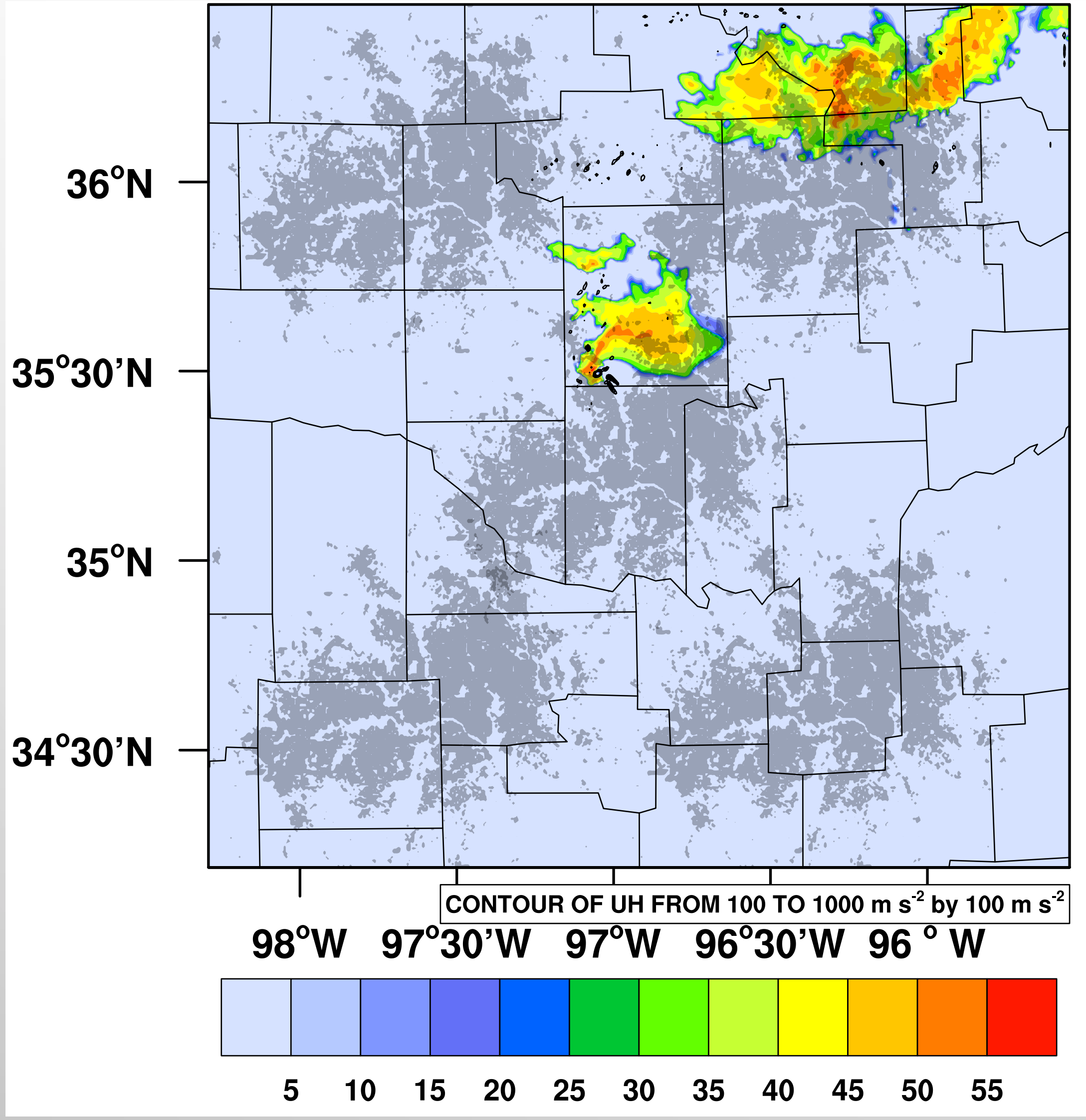
Main question: How does city location relative to storm location and life cycle change storm strength and morphology?

MODEL SETUP

- **2013 May 31 0600 UTC – June 01 0300 UTC**
- ICs and BCs provided by **RAP**
- Parameterizations:
  - NASA Goddard SW / LW
  - Noah LSM
  - MM5 Surface Layer
  - YSU PBL
  - NSSL Microphysics
- Domains:
  - d01: 300 x 300 x 120; 4500 m horiz. Grid; 6 s time step
  - d02 : 400 x 400 x 120; 1500 m horiz. grid; 2 s time step
  - **d03 : 498 x 498 x 120; 500 m horiz. grid; 1 s time step**



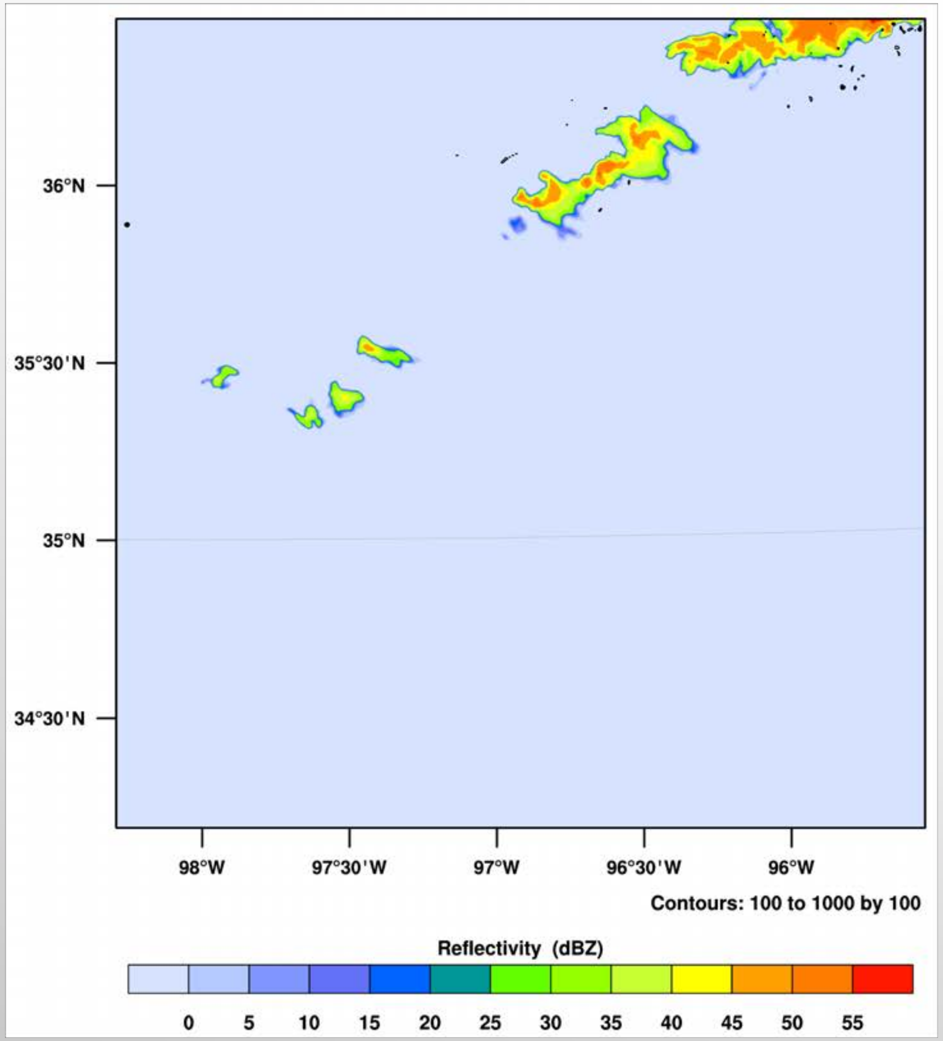
SIMULATION DESIGN

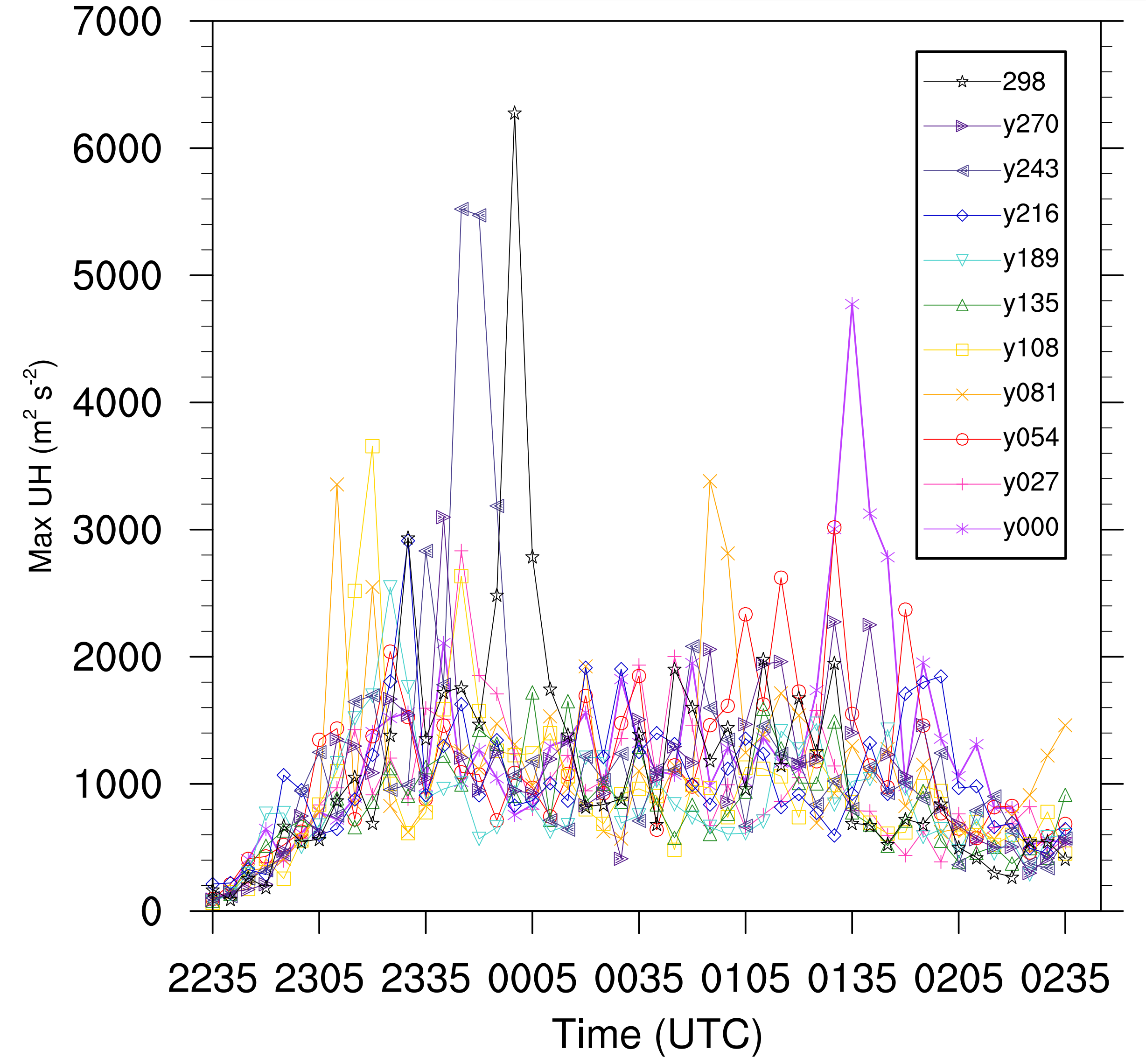


- 9 x 12 matrix of city (DFW) locations (108)
- Each run: 498 x 498 x 120: ~30 million points, 1 s time step
- Same as before: 15 nodes, 32 processes each
- Performance:
  - Average Δt : 2.18s
  - Larger domain
  - ~1.3s beginning run
  - more microphysics = more time

$$UH = \int_{2km}^{2km} \zeta(z) w(z) dz$$

PRELIMINARY RESULTS





WHAT'S NEXT?

- Try different cities, real and idealized
- Factor separation – heat island or surface roughness?

ACKNOWLEDGEMENTS

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