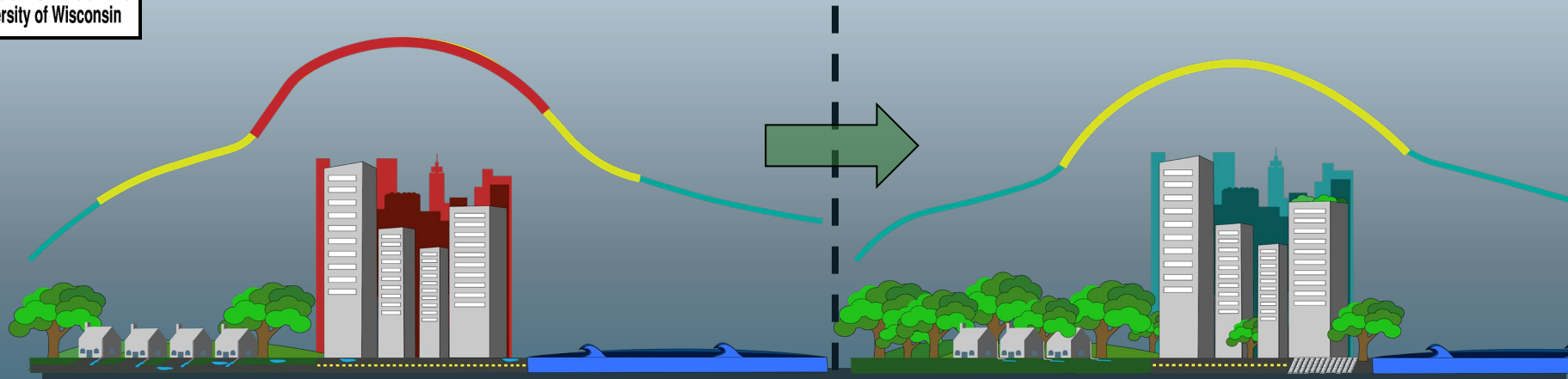


How Adoption of Green Infrastructure Impacts Urban Hydrologic-Atmospheric Processes

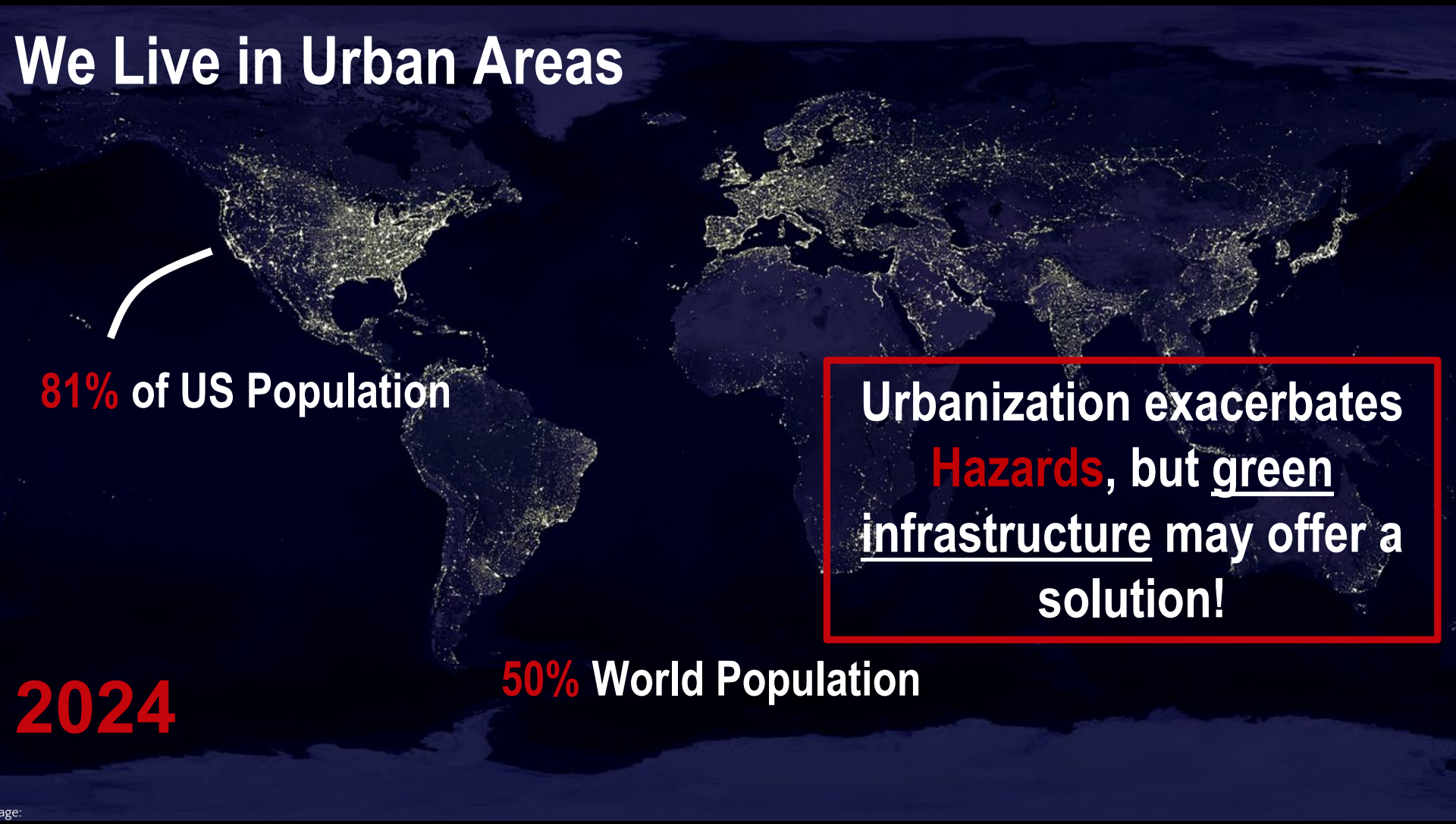
G. Aaron Alexander

Carolyn B. Voter

Steven P. Loheide II

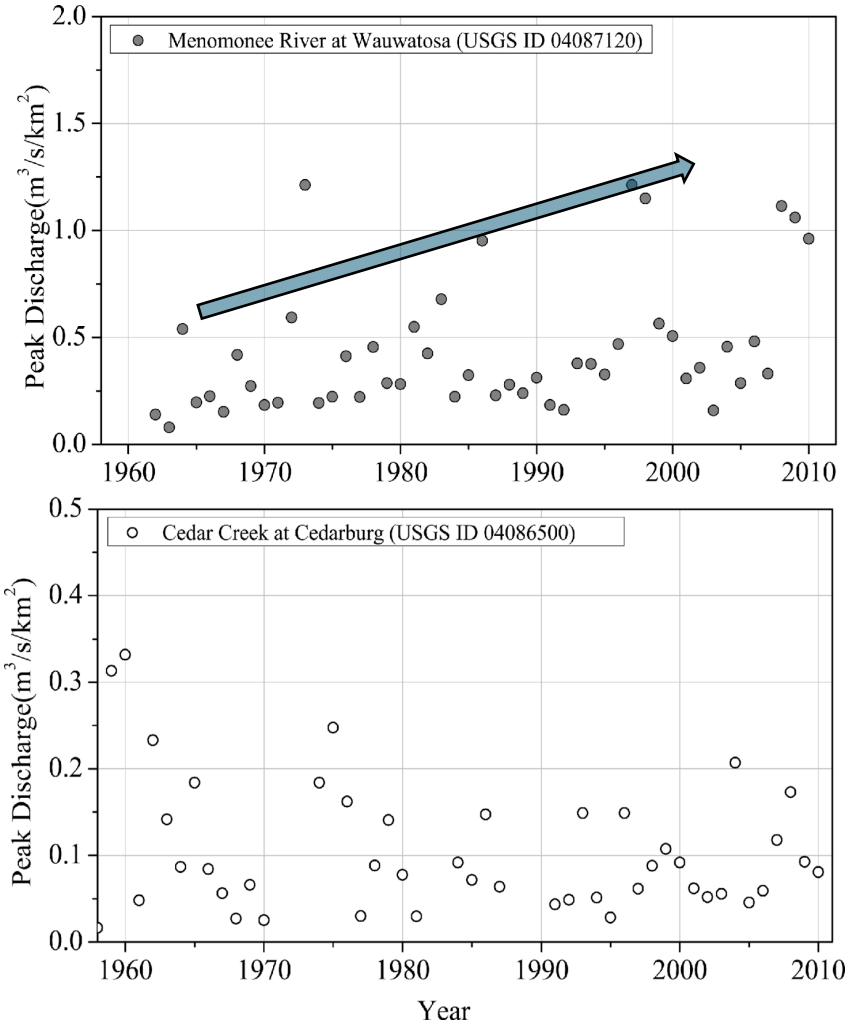
Daniel B. Wright

College of Engineering
UNIVERSITY OF WISCONSIN–MADISON


We Live in Urban Areas
81% of US Population
Urbanization exacerbates Hazards, but green infrastructure may offer a solution!
50% World Population
2024

age:

Urban Hazard: *Flooding*



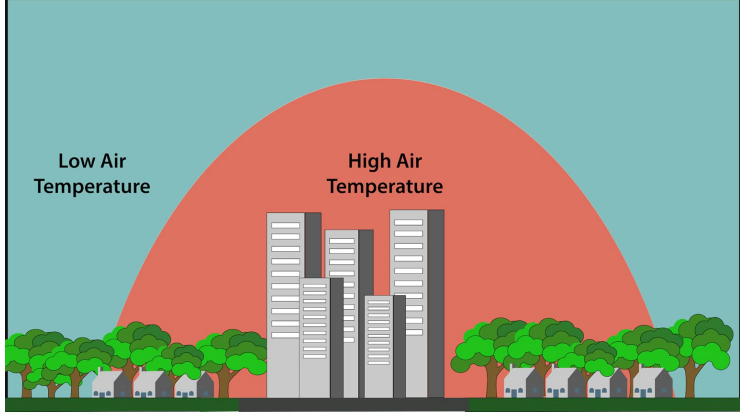
Modified Figure 4 from Yang et al 2013

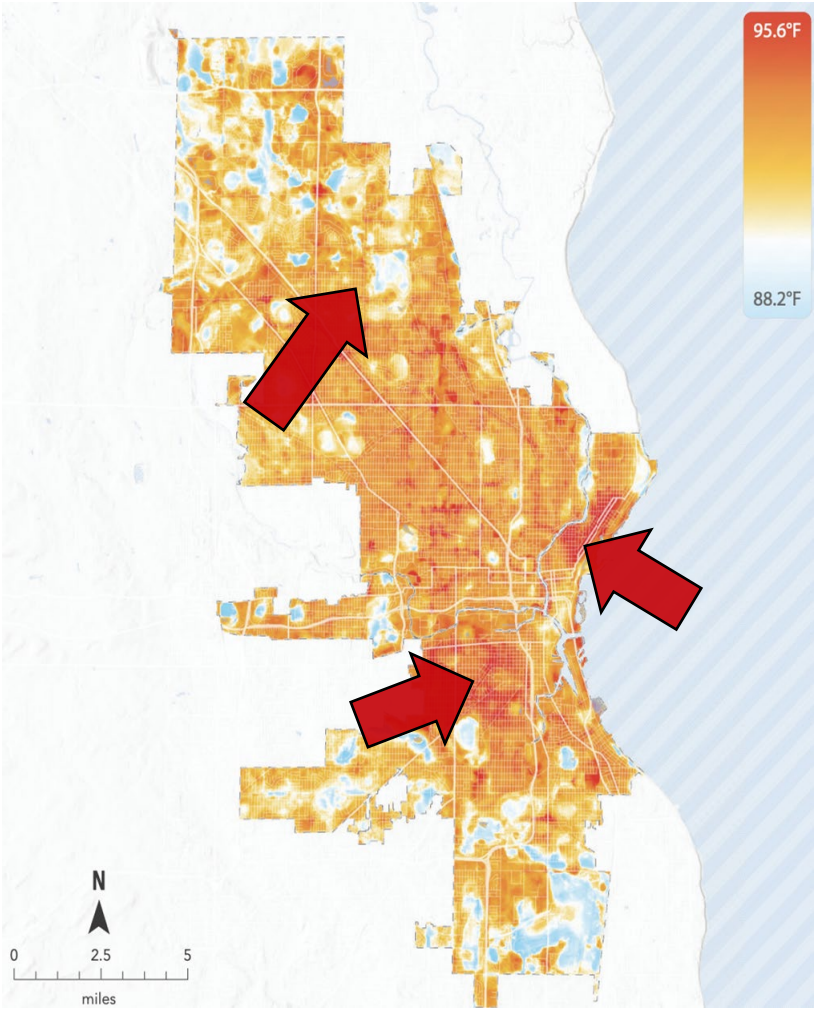
Katy Kildee / Midland Daily News, 19 May 2020

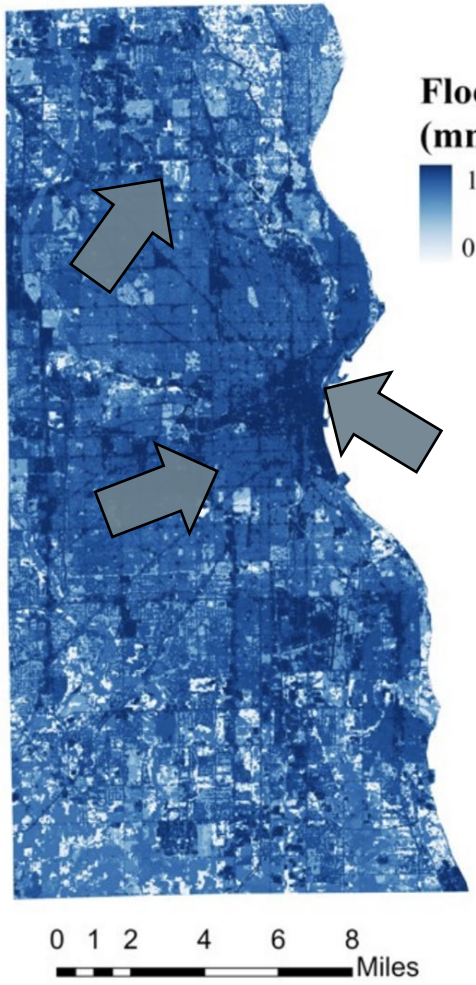
Modified Figure 4 from Tang et al. 2022

Driven By Enhanced Runoff From Impervious Surfaces

Urban Hazard: *Heat*



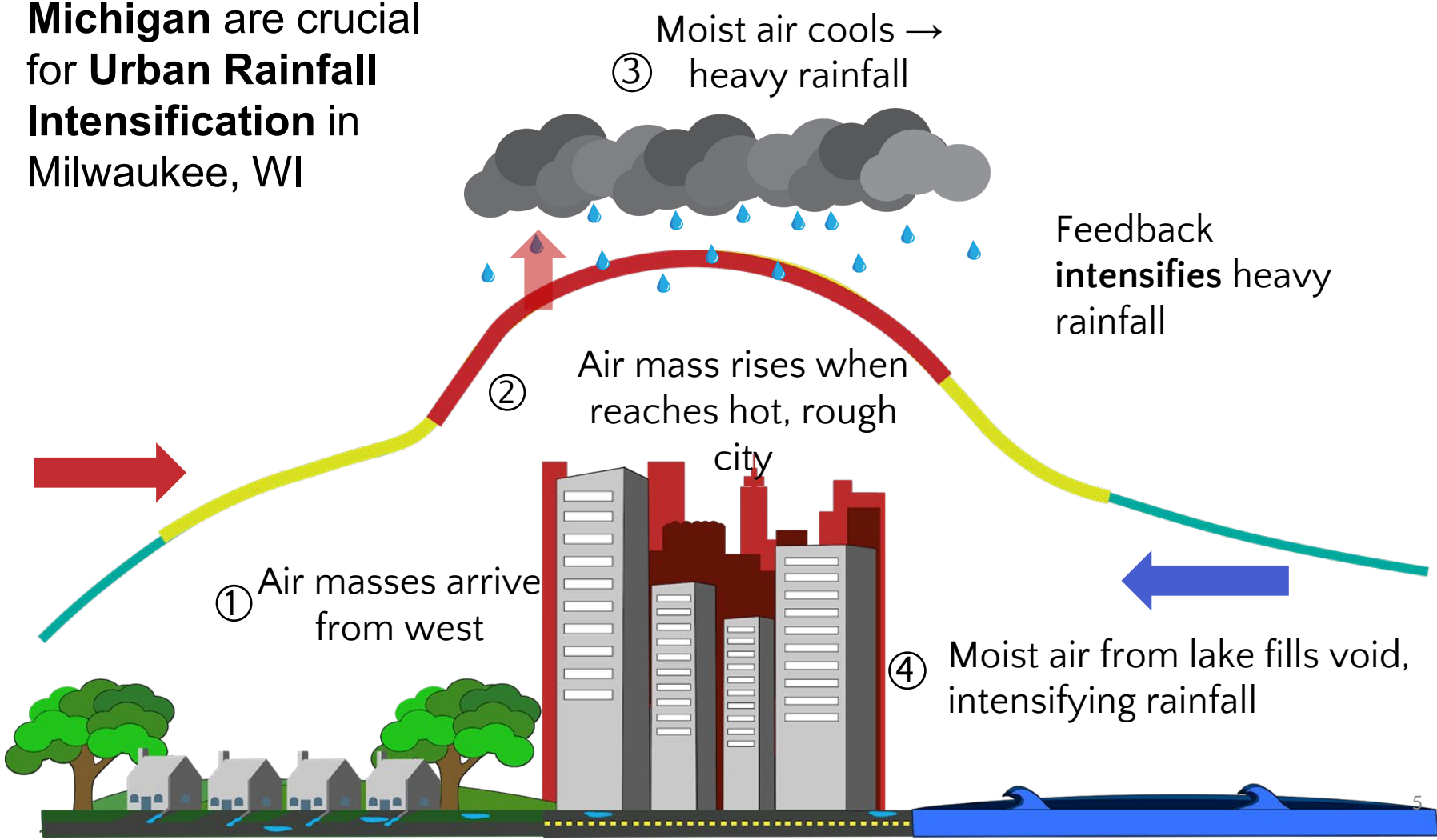




Related to hydrologic Impacts!

Urban Rainfall Intensification

Both **Urban Heat Islands** and **Lake Michigan** are crucial for **Urban Rainfall Intensification** in Milwaukee, WI

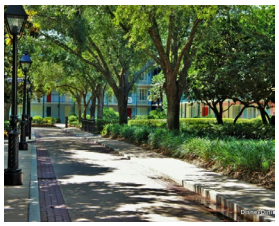


How do we Adapt to these Hazards?

Green Infrastructure

How do we Adapt to these Hazards?

Green Infrastructure

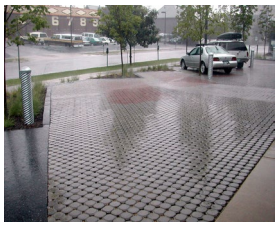


Increase Tree Canopy

Downspout Disconnection

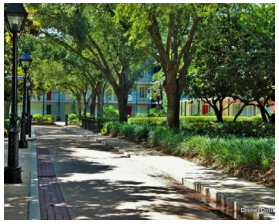
Green Roofs

Permeable Pavement



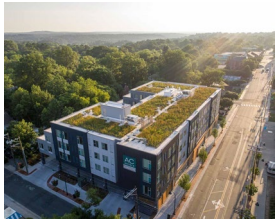
How Does Widespread Green Infrastructure Change Things?

Milwaukee's Green Infrastructure Targets:

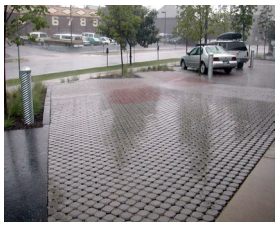


~50 Km^2
Tree Canopy
Increase

~39 Km^2
Downspout
Disconnection

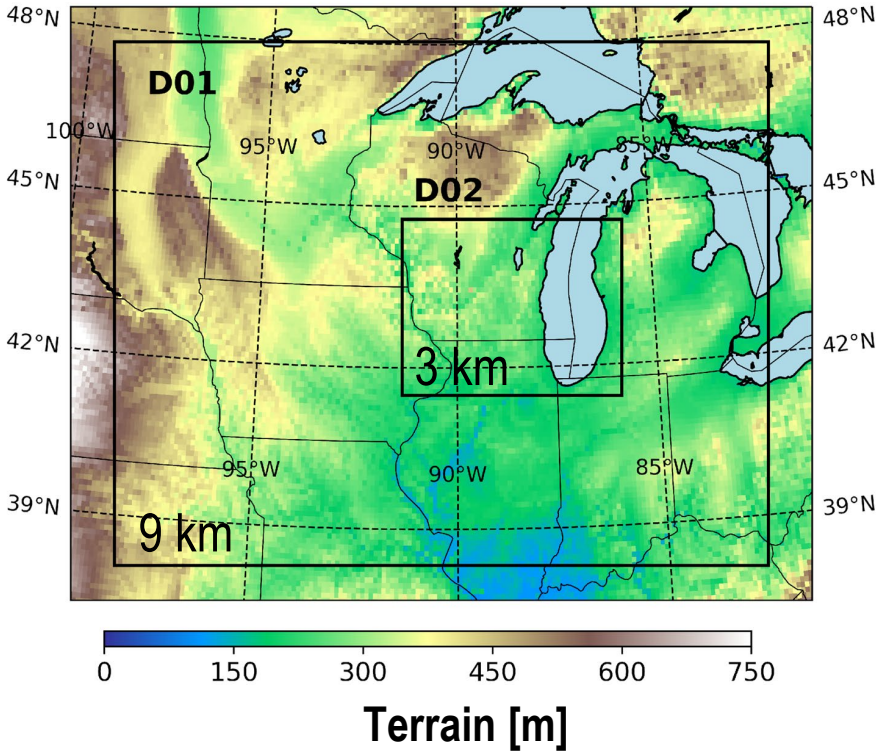


~ 6 Km^2
Green Roofs



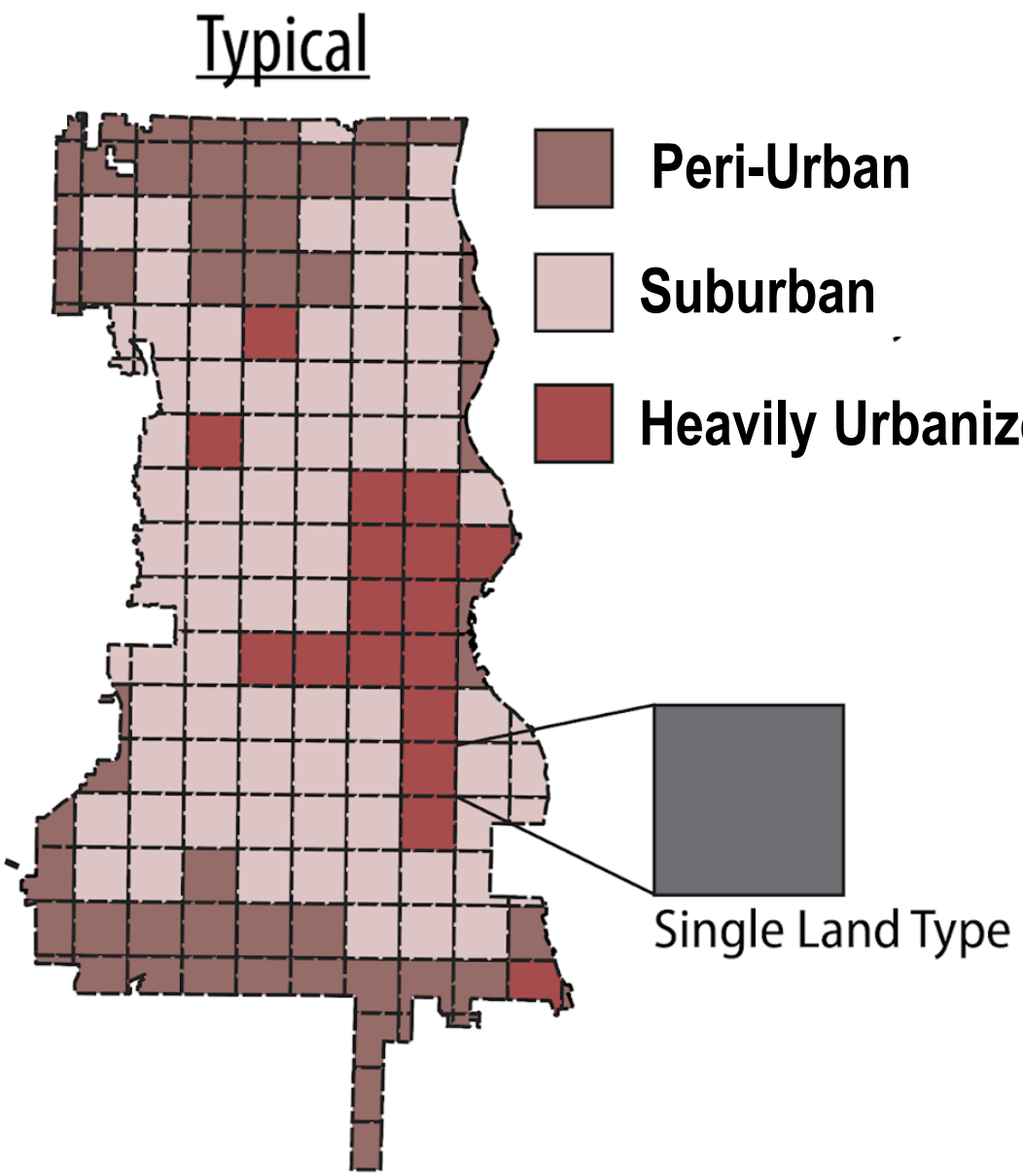
~5 Km^2
Permeable
Pavements

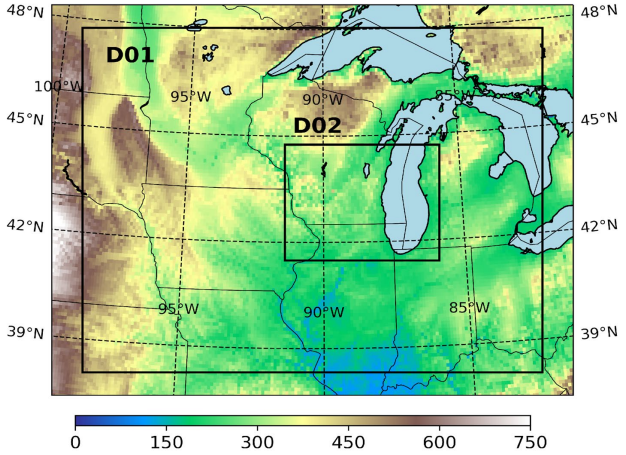
Objective: Evaluate how green infrastructure changes atmospheric responses ahead of, during, and after rainfall events.



Using the Weather Research and Forecasting (WRF) Model:

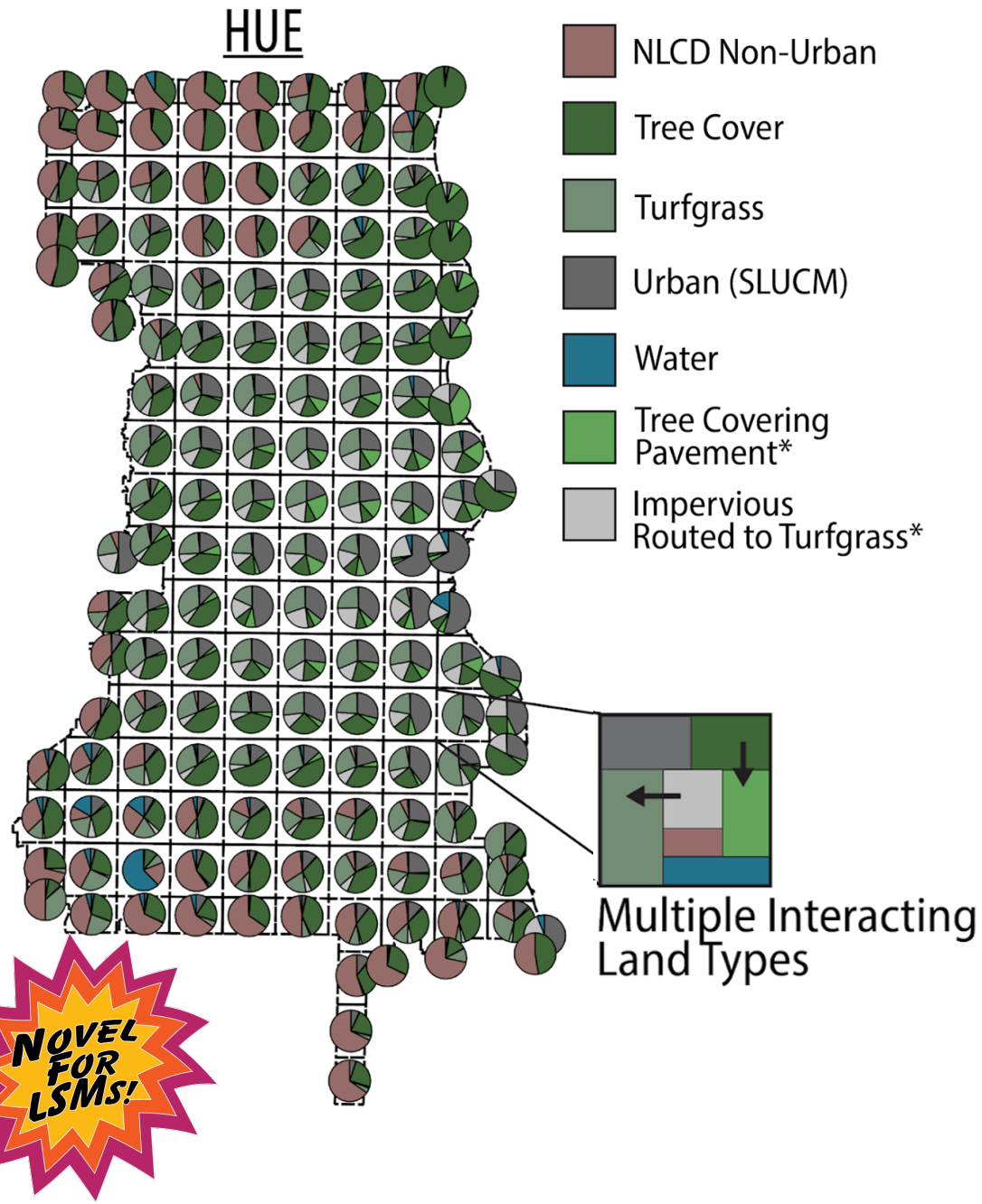
- Simulate **11 Summertime Rainfall Events** in the Milwaukee (from 2014 – 2021)
- **Two simulations** per event based on differing surface representation (22 total)
- Aggregated events together to **identify patterns**

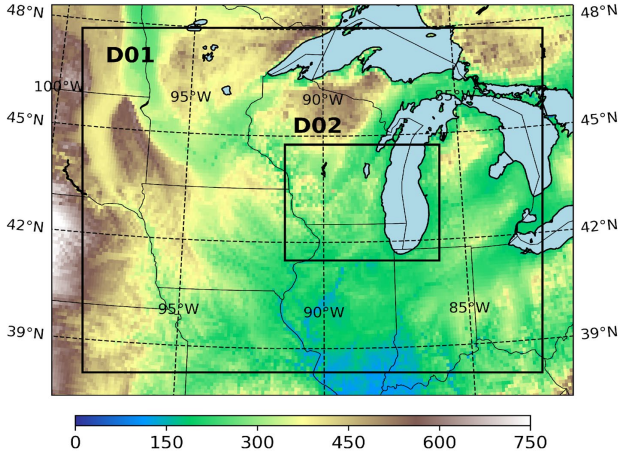




Land Surface Representation

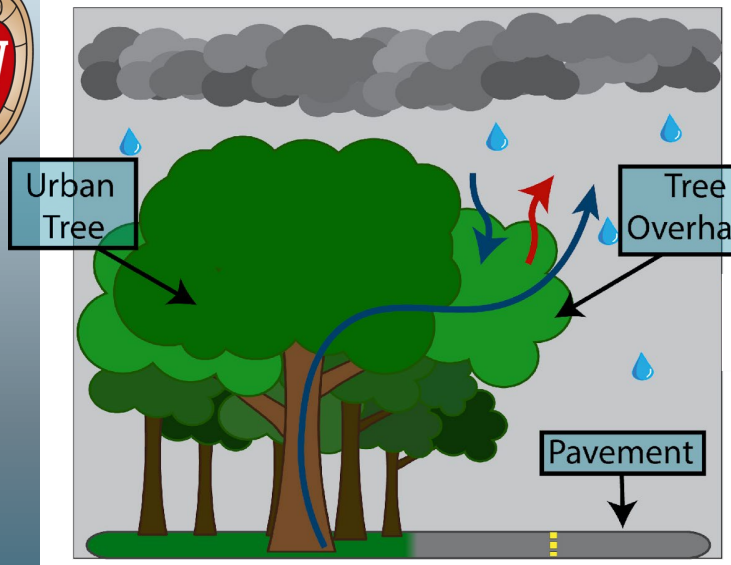
Typical: "out-of-the-box" WRF with NLCD landcover





Land Surface Representation

HUE: Multiple landcover types and representing commonly overlooked hydrology in regional atmospheric simulations



New Water Flux

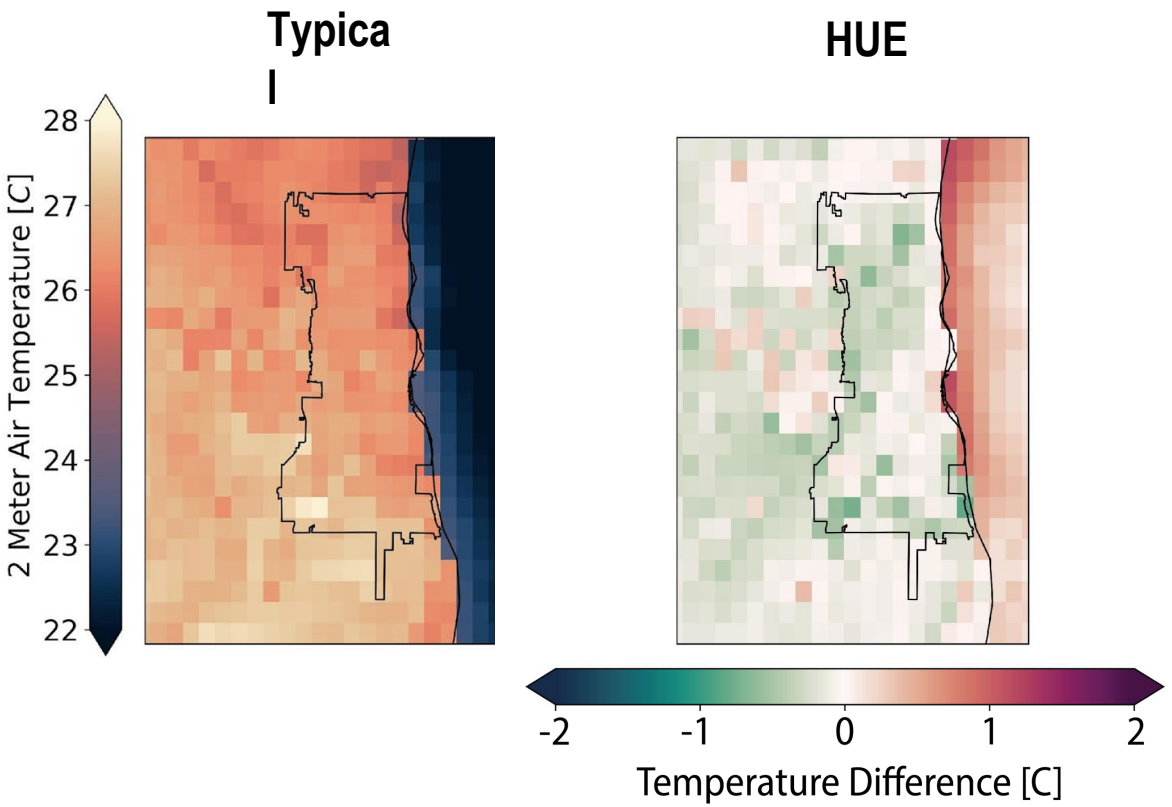
Resulting New Energy Flux

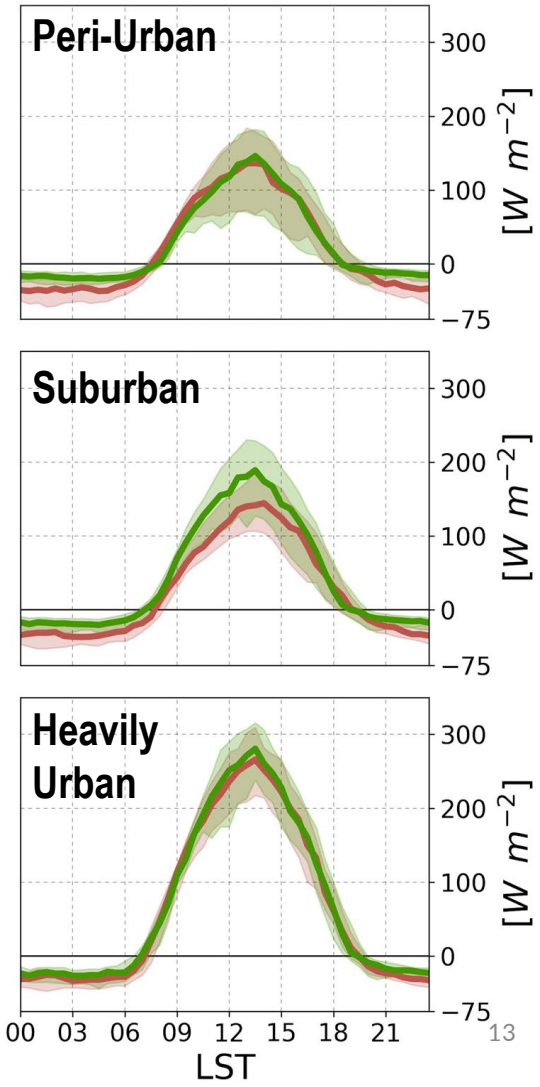
Land Surface Representation

HUE: Multiple landcover types and representing commonly overlooked hydrology in regional atmospheric simulations

Link to Paper Describing Noah-MP HUE!

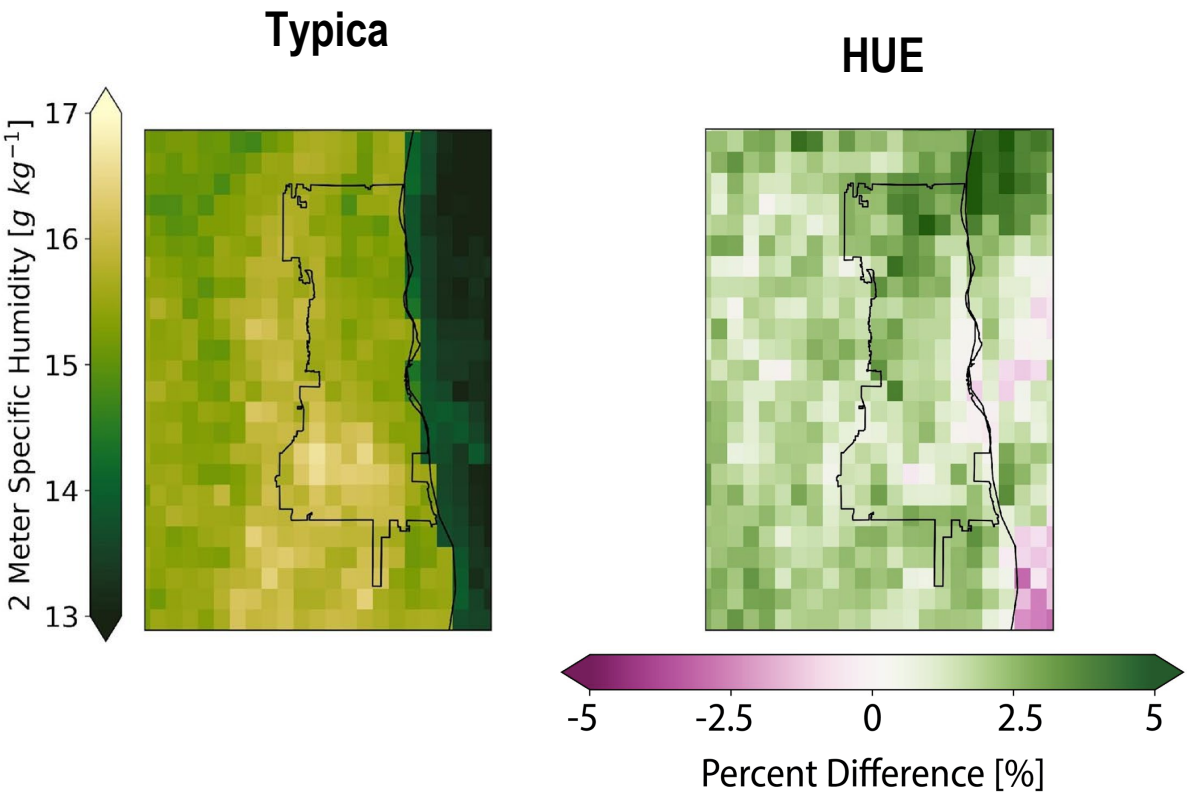
Peak 2m Air Temps & Sensible Heat Fluxes

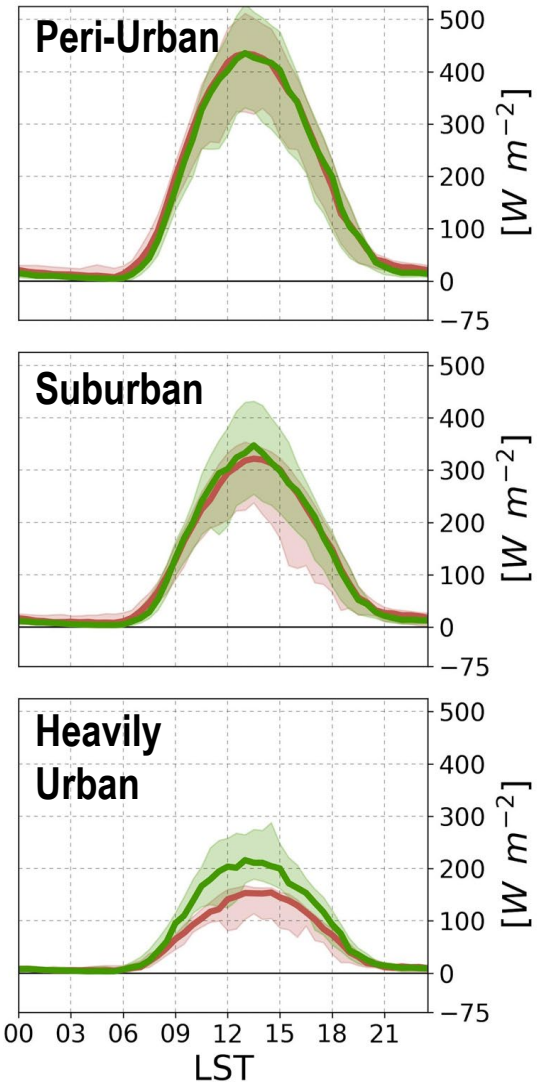




Takeaway: Higher sensible heat in urban locations in HUE due to *energetic effects,* resulting in higher average 2m air temperatures some locations compared to typical

Peak Surface Humidity & Latent Heat Fluxes

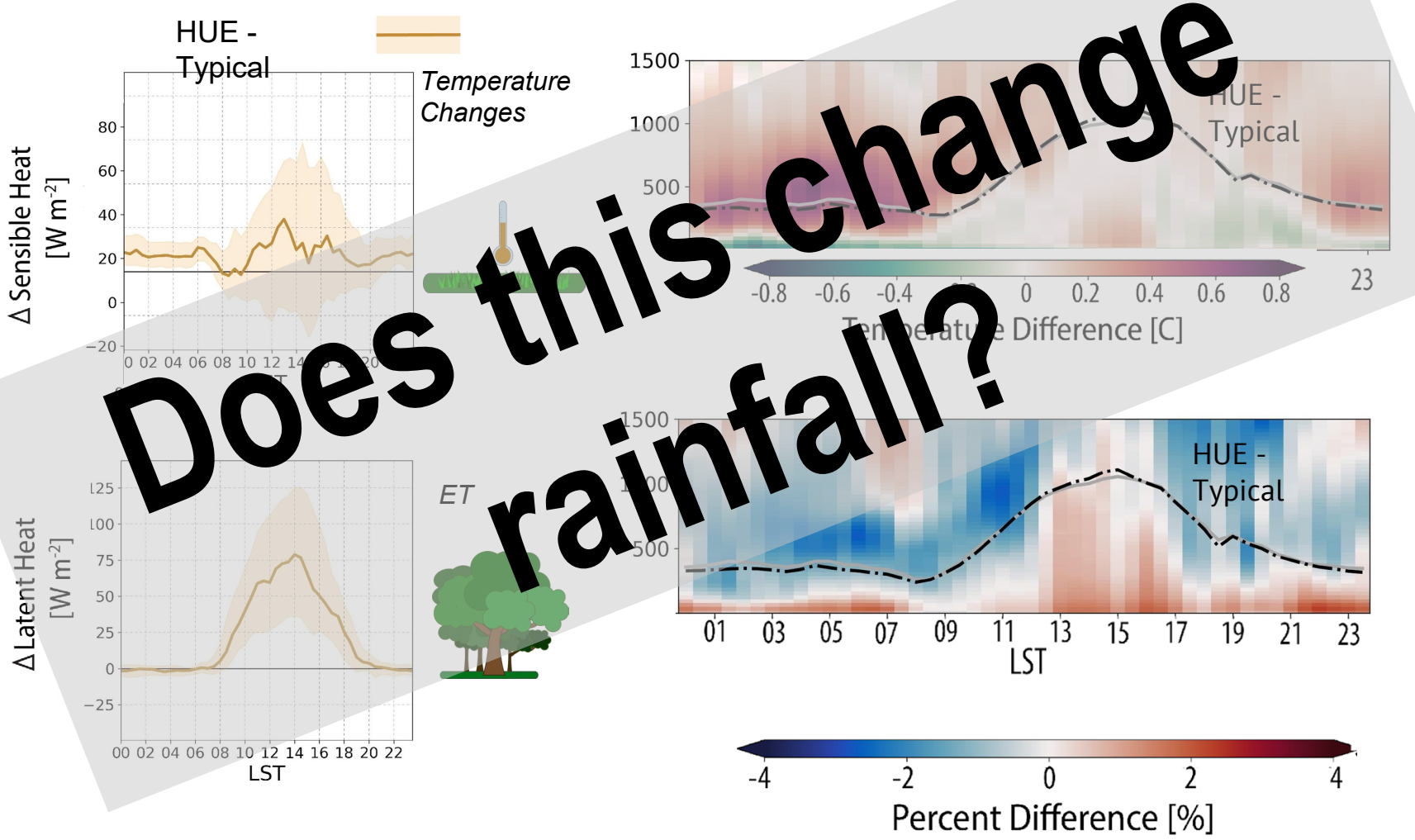




Takeaway: Higher latent heat in urban locations in HUE due to *more vegetation.* Humidity mostly enhanced, though heterogeneity is present!

Atmospheric Consequences?

Look for upcoming publications examining land-atmosphere couplling



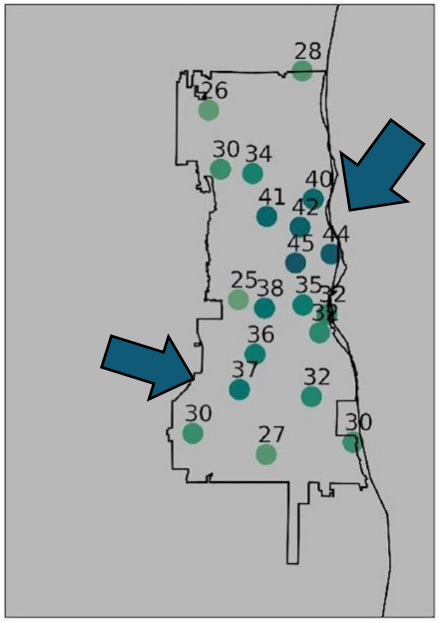
Effects on Average Rainfall Totals

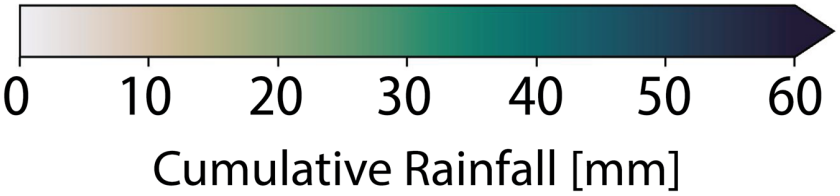
Takeaway: More realistic representation of urban rainfall intensification present in observations when **averaging over events**

Typica

HUE

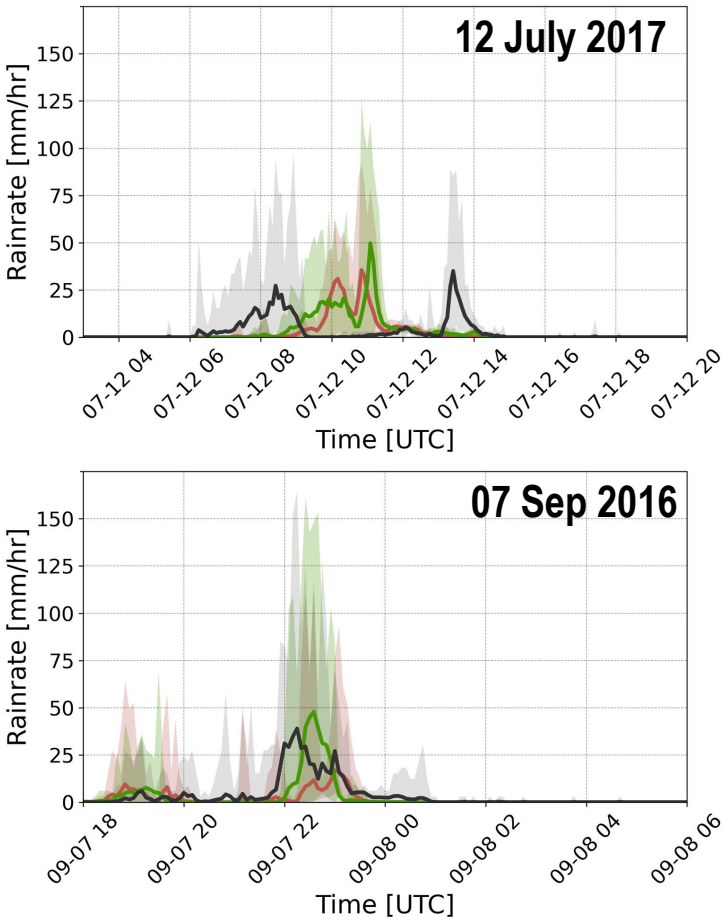
MMSD OBS



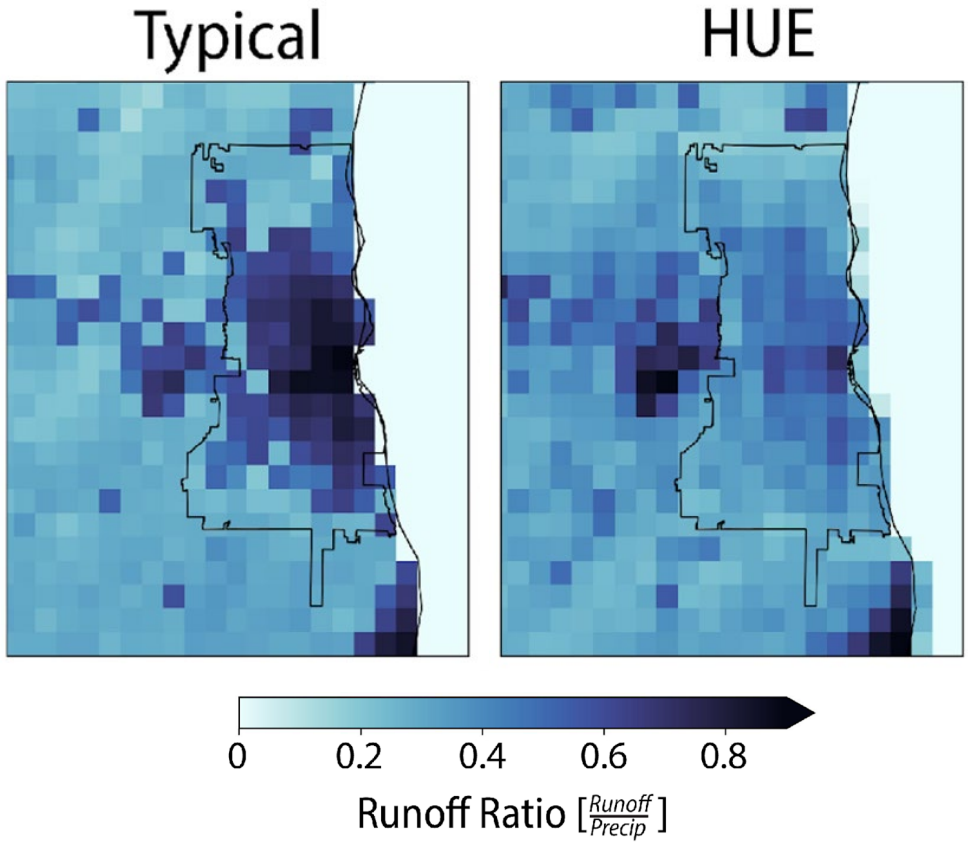


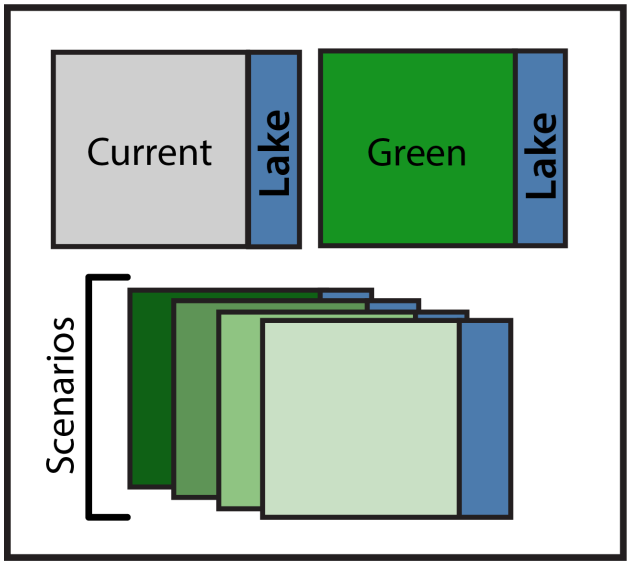
Effects on Rainfall Intensity

Still suffer from large scale forcing error, but HUE results in [better rainrate estimates]



Implications for Runoff and Climate Mitigation





What happens when we start to infiltrate more rainfall in Cities to coupled atmospheric processes? Will this further change urban climates?

Key Points:

- We've developed a land surface model **explicitly resolving** urban heterogeneity and vegetation through the lens of surface water transfers (***Soon to be in National Noah-MP***)!
- Sub-grid processes have drastic **energy partitioning**, resulting in **changes to air temperature and humidity.**
- Heterogeneity and vegetation integration leads **to more realistic rainfall simulations** (in Milwaukee, but potentially other locations)!

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Hydroclimate Extremes Research Group

Hydroecology Lab Group

NCAR UCAR | CISL Computational & Information Systems Lab

NCAR's high-performance computing support from Derecho (doi:10.5065/D6RX99HX)

Sea Grant University of Wisconsin

Link to Paper Describing Noah-MP HUE!