How Adoption of Green Infrastructure Impacts Urban Hydrologic-Atmospheric Processes

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We Live in Urban Areas

81% of US Population

2024

50% World Population

Urbanization exacerbates Hazards, but green infrastructure may offer a solution!
Urban Hazard: Flooding

Driven By Enhanced Runoff From Impervious Surfaces

Modified Figure 4 from Tang et al. 2022
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 Km² Tree Canopy Increase
- ~39 Km² Downspout Disconnection
- ~6 Km² Green Roofs
- ~5 Km² 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**
Typical

Peri-Urban
Suburban
Heavily Urbanized

Land Surface Representation

Typical: “out-of-the-box” WRF with NLCD landcover
HUE: Multiple landcover types and representing commonly overlooked hydrology in regional atmospheric simulations.
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Link to Paper Describing Noah-MP HUE!
Permissions: Higher sensible heat in urban locations in HUE due to \textit{energetic effects}, resulting in higher average 2m air temperatures some locations compared to typical.

\textbf{Takeaway:}
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 coupling

Does this change rainfall?
Effects on Average Rainfall Totals

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