Assessing the Impact of Heat Mitigation Strategies in Urban Ecosystems using ASLUM-Py

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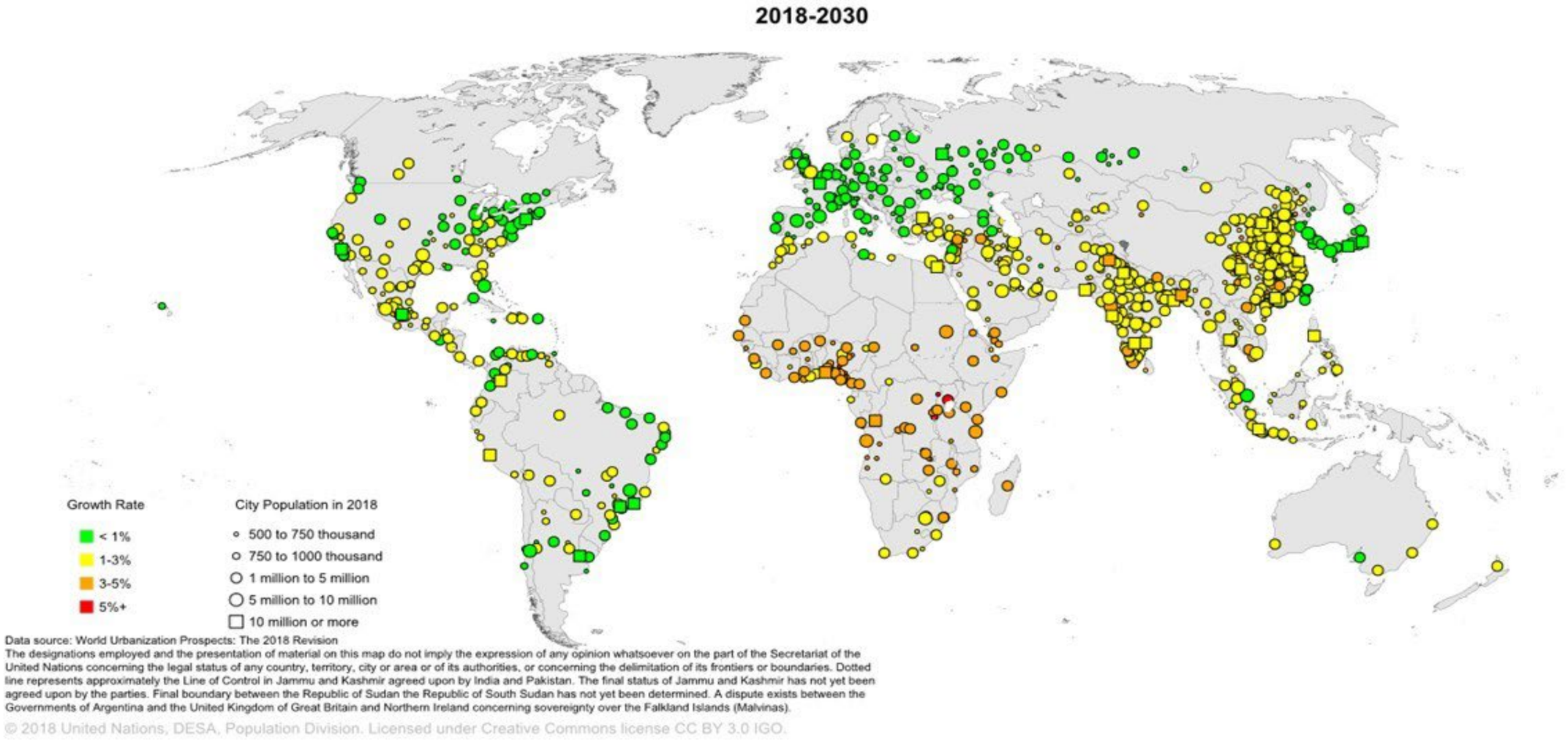
School of Sustainable Engineering and the Built Environment, Arizona State University

AMS American Meteorological Society

ASU Arizona State University

01/14/2025

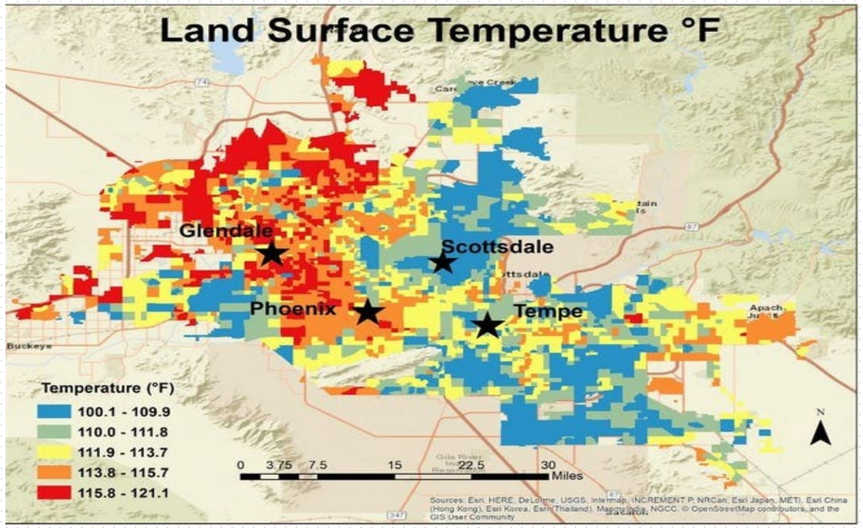
UN world urbanization prospects



Global urban facts:
3% of global land surfaces; 56% human population; ~67%-76% of global energy; ~¾ of global carbon emissions

Urban Environmental Challenges

Urban heat islands (Phoenix): Extreme temperatures exacerbate energy use and public health issues.



Urban heat island (@Phoenix 08/22/2019)



Air pollution (@Tehran)

Air pollution (Tehran): Health risks and reduced air quality

Flooding (Henan): Vulnerability of urban infrastructure to climate events.



Flooding (@Henan China, 08/02/2021)

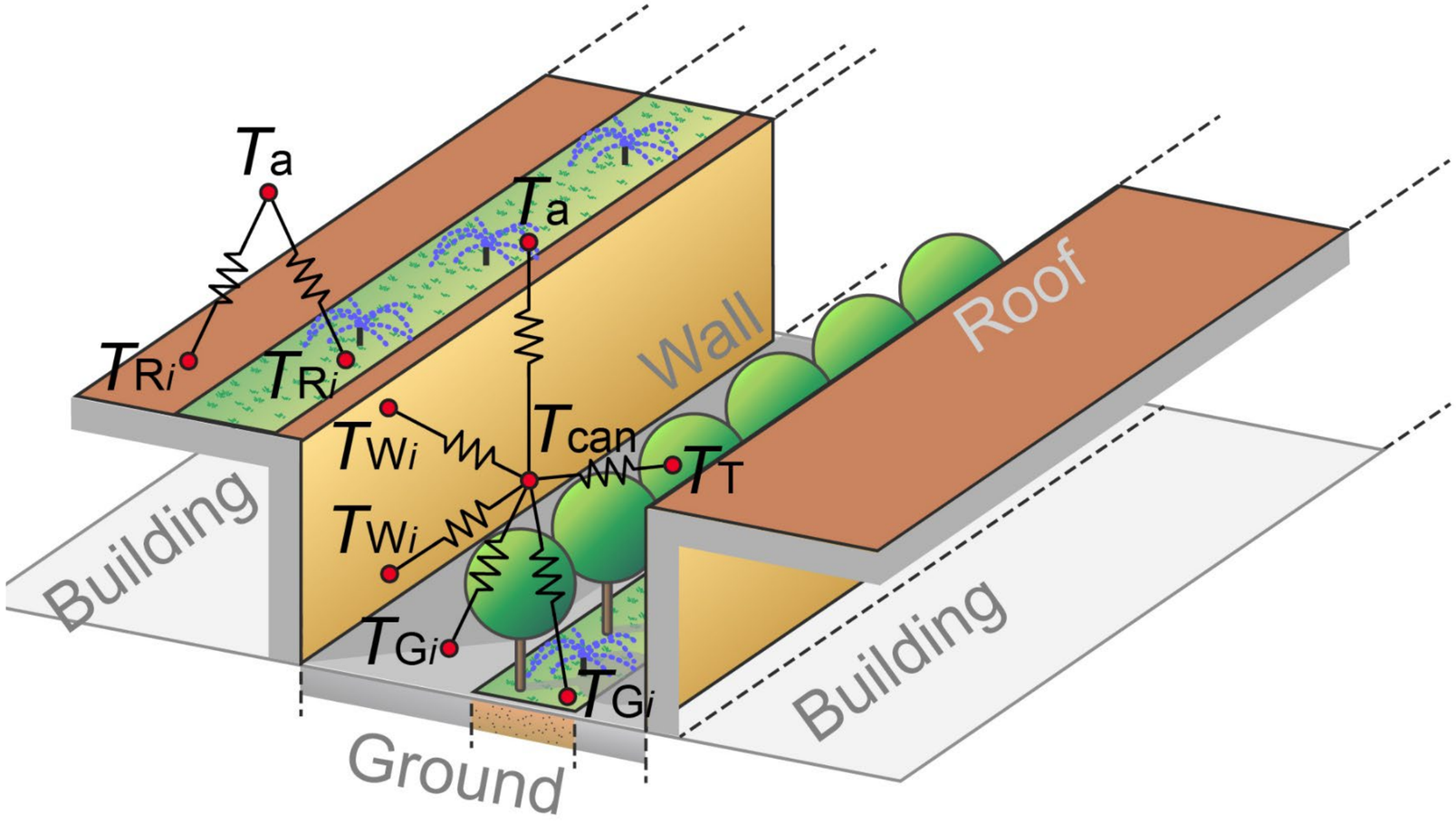


Water shortage (@Chennai India, 08/2019)

Water shortages (Chennai): Strains on resources in growing cities.

Arizona Single Layer Urban Model (ASLUM) as an Essential Tool

- It's a tool that models urban canopy energy dynamics, including heat fluxes and hydrology
- Simulating the effectiveness of mitigation strategies
- Its ability to assess real-world interventions like green roofs, irrigation, and urban trees



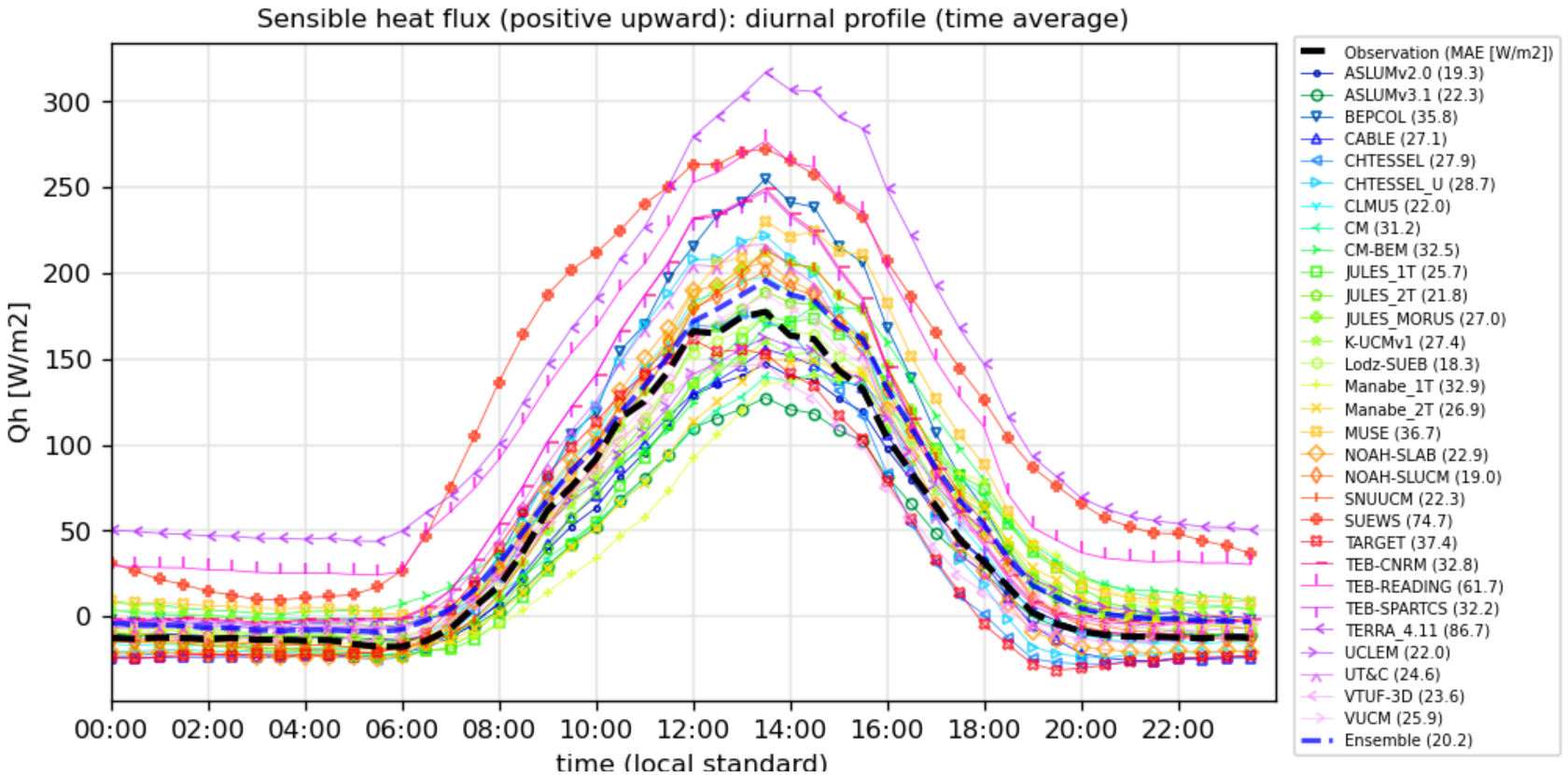
Wang et al. 2021 Build Env.

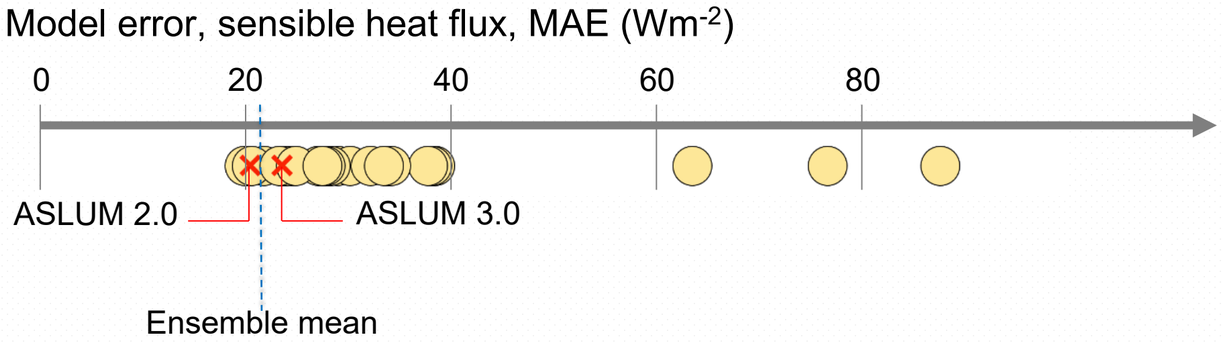
History of ASLUM development

Version	Major feature	References
ASLUM v1.x	Comprehensive urban canopy layer heat exchange, **sub-facet heterogeneity**, basic hydrological processes (ET, infiltration)	Wang et al., 2013 *QJRMS*
ASLUM v2.x	**Green roofs**, urban vegetation (lawn) and irrigation, anthropogenic heat, oasis effect	Yang et al., 2015, *BLM*; 2016, *JHM*
ASLUM v3.x	**Urban trees** (radiative shading, leaf transmission)	Wang, 2014; Ryu et al., 2016; Wang et al., 2021

Coupling with external components: Lagrangian Stochastic model for pollutant transport (Wang et al., 2018), large eddy simulations (Li and Wang, 2018), machine learning & optimization (Li et al., 2022), Web-based (Python) interfacing (on-going)

Global urban LSM intercomparison



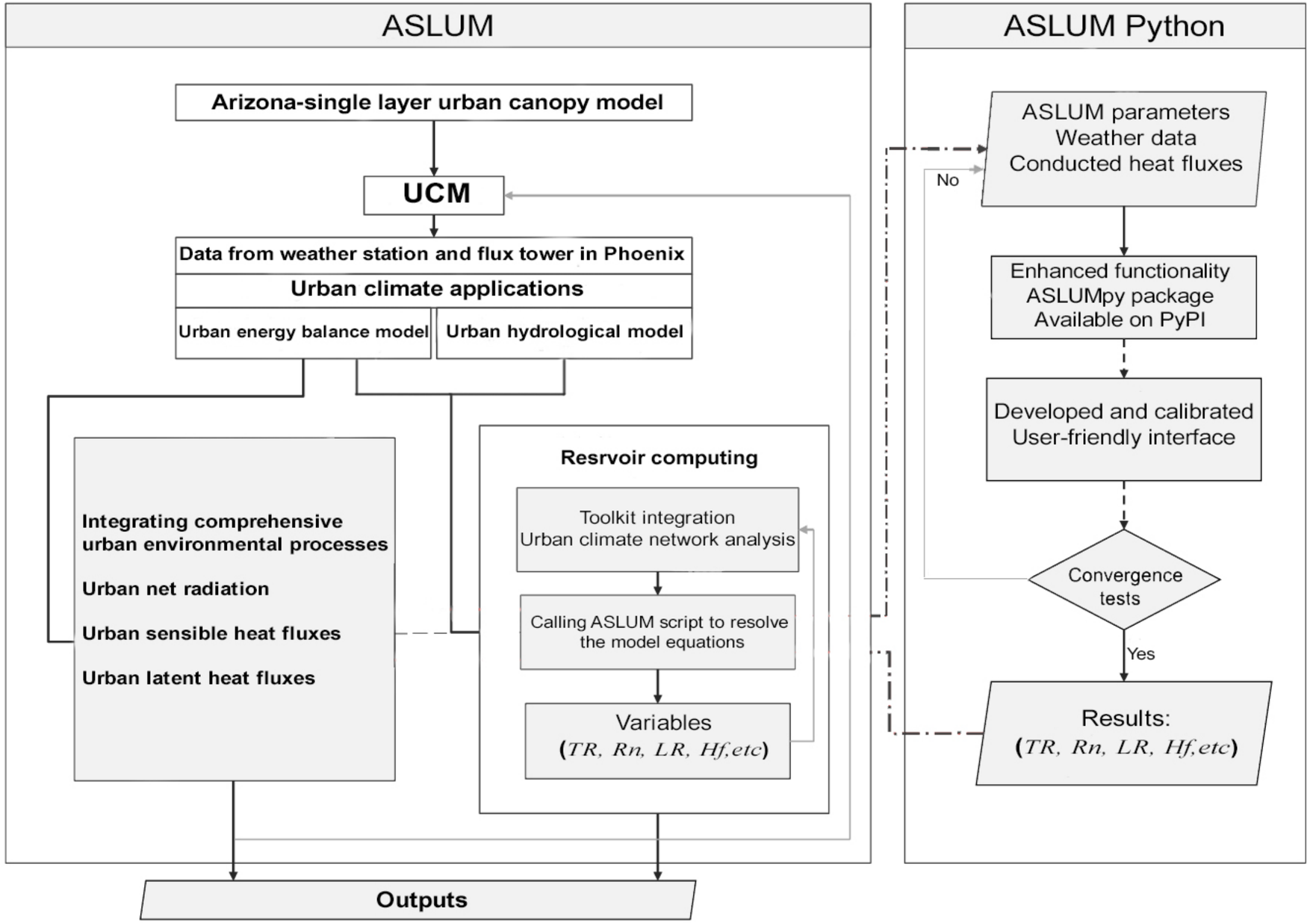


Lipson et al., 2021, Urban-PLUMBER
https://urban-plumber.github.io/AU-Preston/plots/baseline/AU-Preston_baseline_Qh.png

ASLUM Python Integration

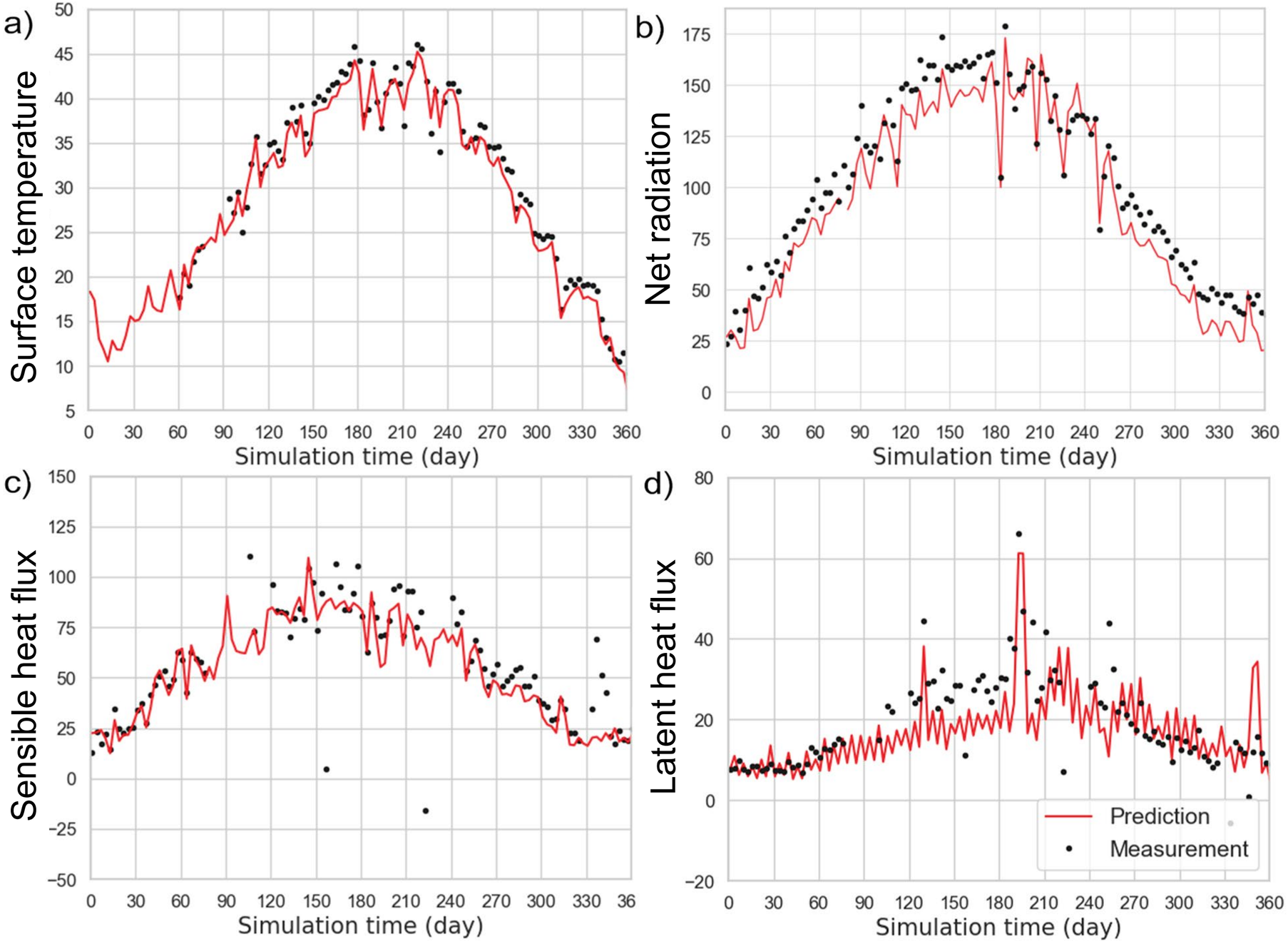
ASLUM-Python is calibrated against field measurements using weather stations and eddy-covariance flux towers, with applications to different roofing technologies for **urban heat mitigation**.

It makes urban climate modeling more **flexible and accessible** to a wider range of users.
This user-friendly design helps bridge the **gap between complex climate science and practical urban applications**.



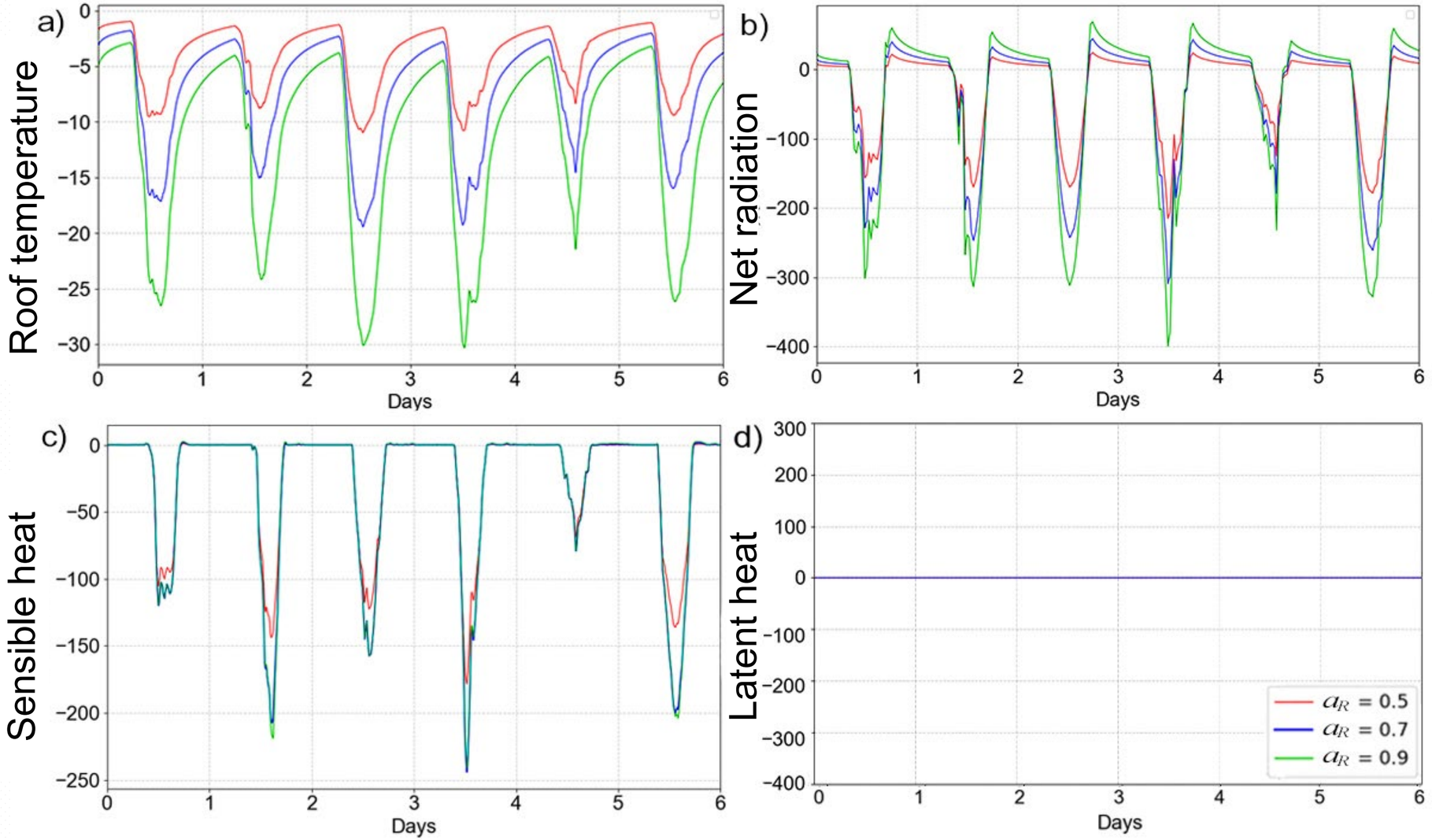
Rahmatollahi et al. (Under Preparation).

Validation


a)
Surface temperature
Simulation time (day)
b)
Net radiation
Simulation time (day)
c)
Sensible heat flux
Simulation time (day)
d)
Latent heat flux
Simulation time (day)
Prediction
Measurement

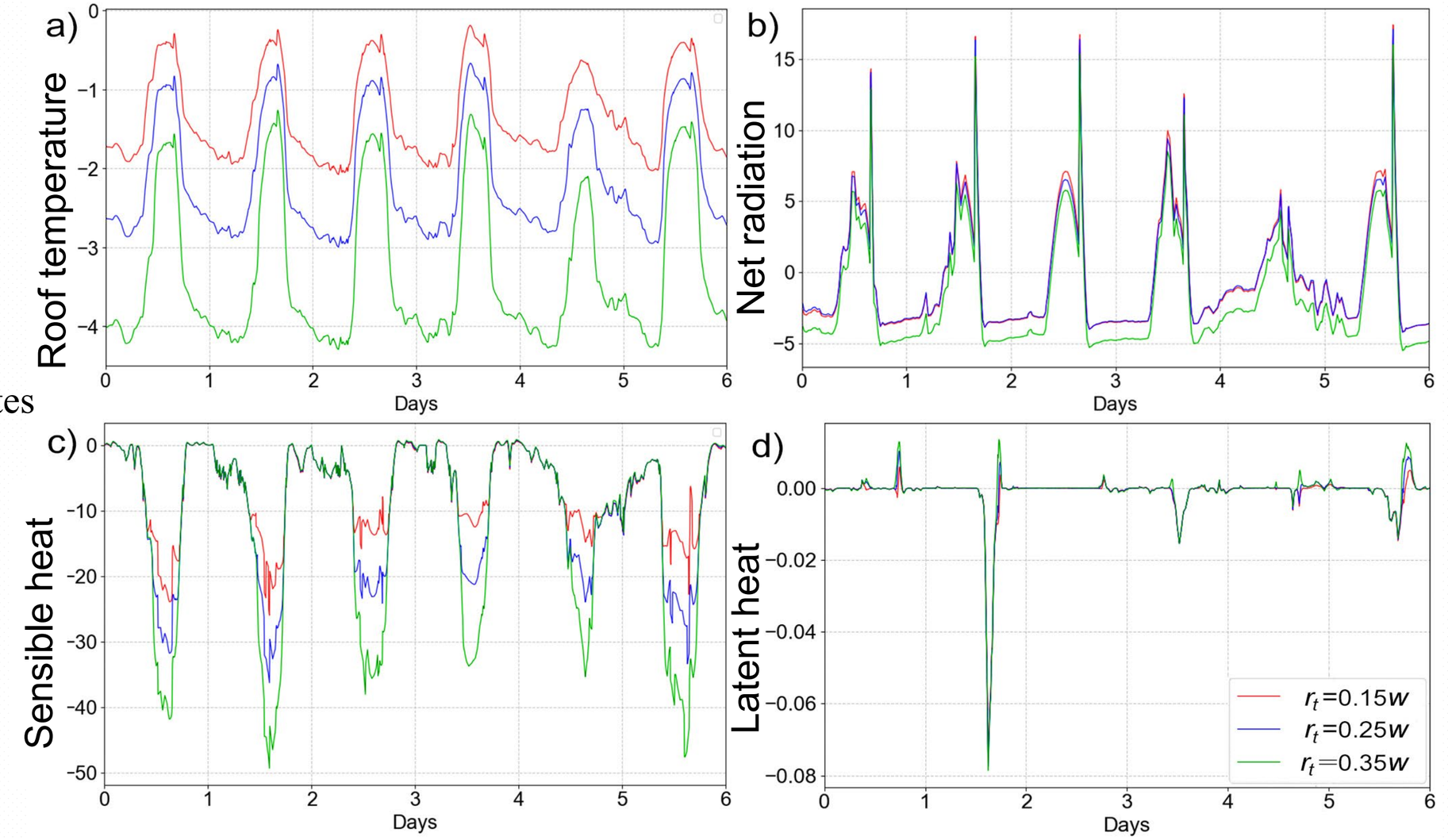
Roof Surface Temperature

The impacts of varying roof albedo (aR=0.5, 0.7, 0.9) over six days.



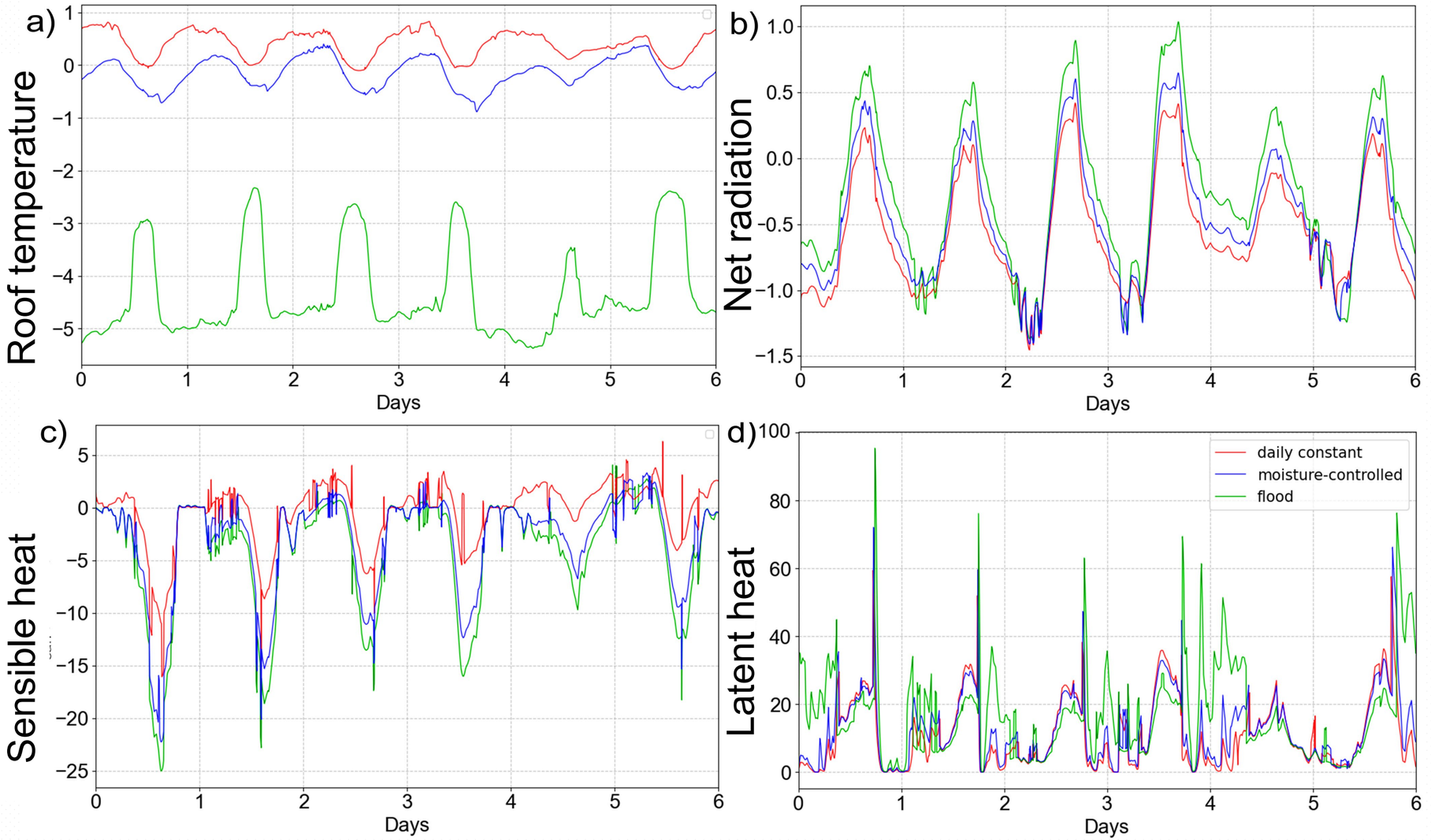
Tree Crown Size

The impacts of varying irrigation rates (rt=0.15w, 0.25w, 0.35w) on urban canopy variables over six days.



Irrigation Schemes

Different irrigation schemes (daily constant, moisture-controlled, and flood) show significant cooling effects on urban canopy over six days.




ASU
Arizona State
University

Summary

Capacity of ASLUM:

- **Simulates urban canopy processes, offers urban heat mitigation strategies, and validates seasonal variations.**

Advantages of the Python Platform:

- **Has extensive Machine Learning libraries, is open-source, and integrates with Geospatial tools.**

Future Applications of ASLUM-Py:

- **It optimizes heat mitigation using machine learning, estimates long-term urban climate trends, and real-time predictive analysis.**

Acknowledgement









Thank you for your attention!

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