

High-Resolution Urban Heat Mapping for NYC Public Spaces

COLUMBIA URBAN SYSTEMS ENGINEERING LAB

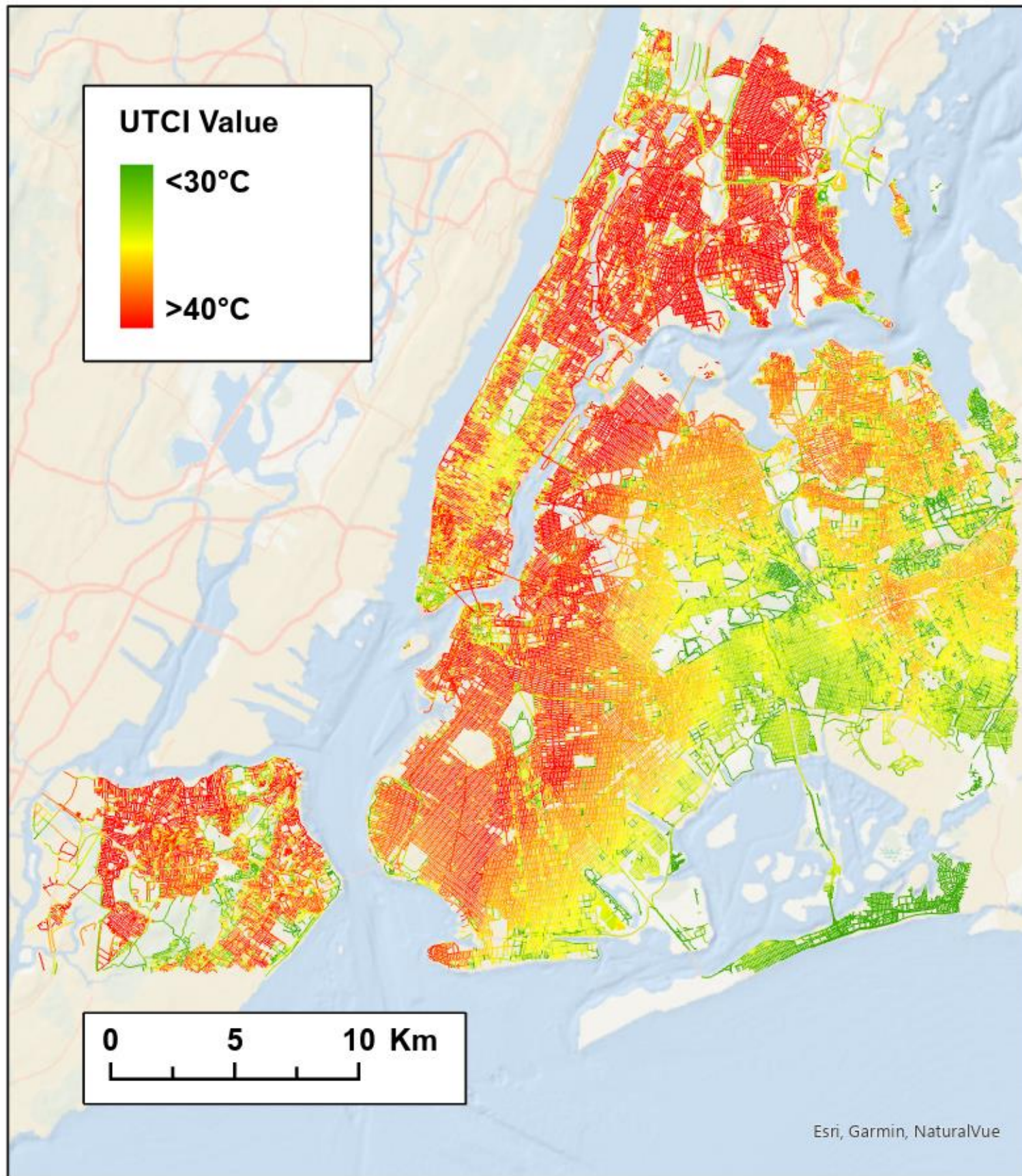
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(UTCI values on street segments)



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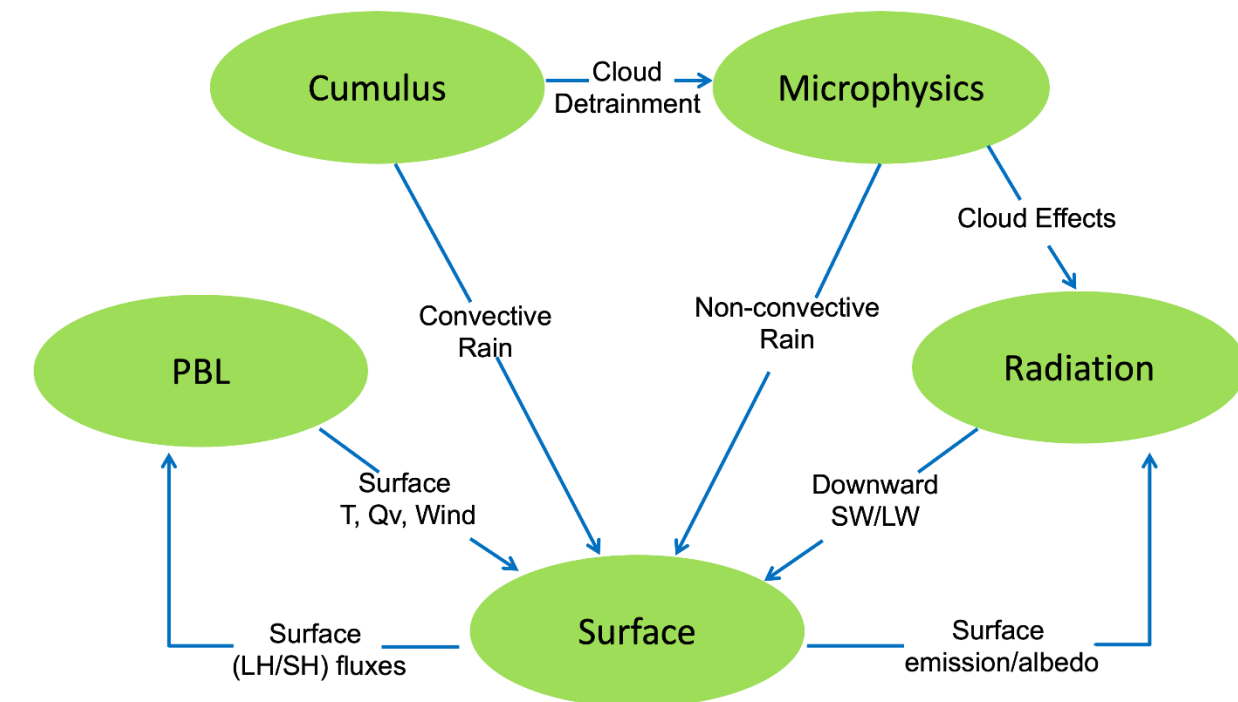
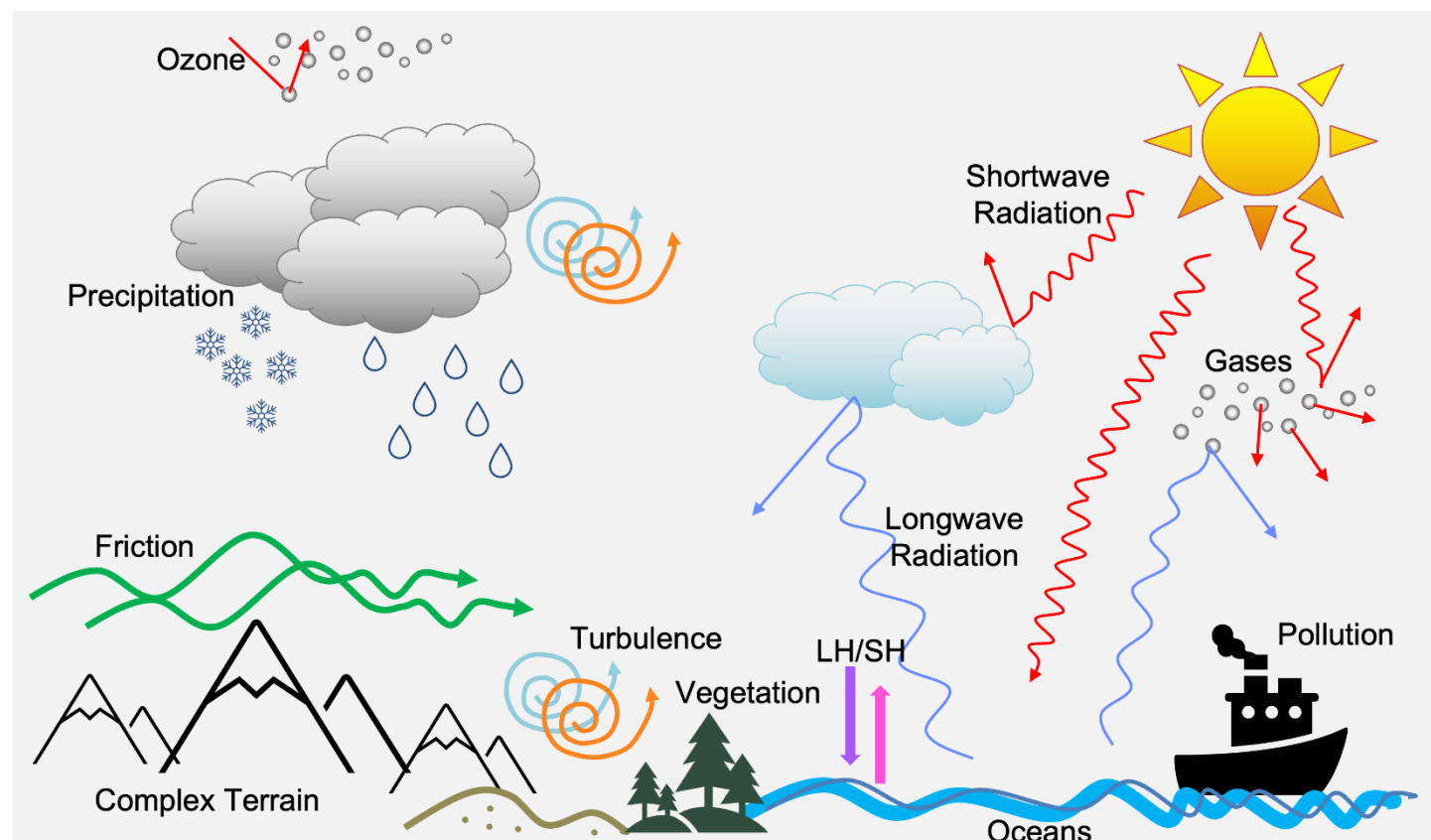
Why Micro-Scale Heat Matters

- NYC wants to locate & cool the hottest public spaces.
- We need hourly, block-level temperature → traditional data (satellite, single weather station) miss the mark.
- Our framework delivers time-dependent, 10m (or less) heat-stress maps that planners can act on.



WRF — The Regional Climate Model

- The WRF model is a flexible, state-of-the-art atmospheric simulation system.
- Types of input:
 - Static geographical data: Elevation, land-use / land-cover maps, soil type.
 - Gridded meteorological data: Dozens of atmospheric and land-soil variables, including temperatures, winds, precipitation, soil moisture, and atmospheric ozone concentration.
- What WRF simulates:



WRF — The Regional Climate Model

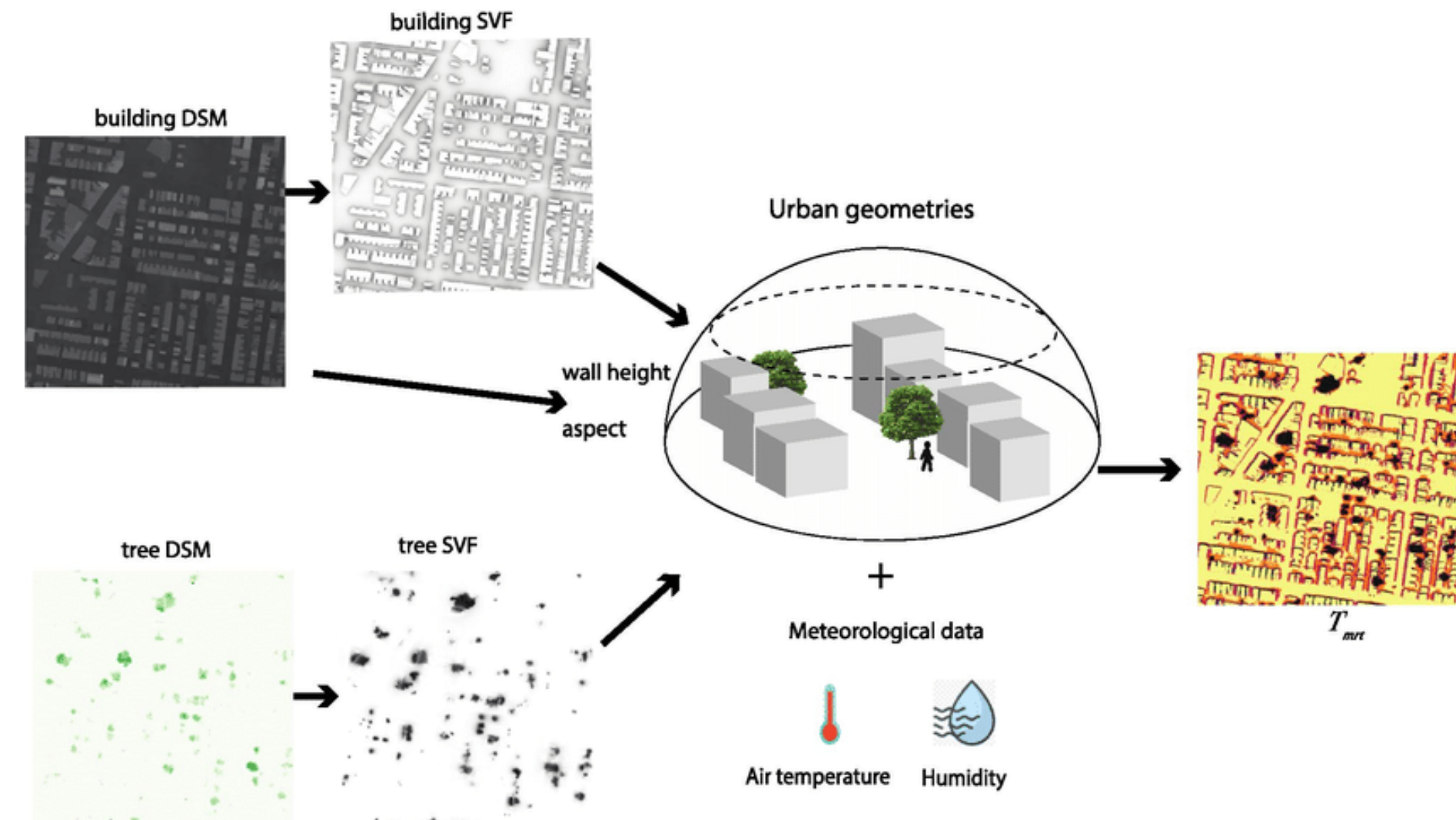
Numerous peer-reviewed and technical studies around the world have already benchmarked WRF's urban configurations against observations, giving planners confidence in its reliability:

- High-Resolution, Multilayer Modeling of Singapore's Urban Climate Incorporating Local Climate Zones. (Mughal et al., 2019)
- Modelling the urban heat island in Singapore – state-of-the-art WRF model technical details. (Mughal, 2020)
- Simulation of urban heat island during a high-heat event using WRF urban canopy models: A case study for Metro Manila. (Bilang et al., 2022)
- Highly resolved WRF-BEP/BEM simulations over Barcelona urban area with LCZ. (Ribeiro et al., 2021)



SOLWEIG — The Local Urban Model

- The Solar and LongWave Environmental Irradiance Geometry (SOLWEIG) model is a lightweight 3-D radiation model that translates urban form into pedestrian-level heat exposure.
- By tracing incoming and reflected short-wave (sun) and long-wave (thermal) radiation from six directions, SOLWEIG produces high-resolution maps of mean radiant temperature, one of the key drivers of human thermal comfort outdoors.



- Inputs: direct, diffuse and global shortwave radiation, air temperature, relative humidity, urban geometry and geographical information (latitude, longitude and elevation). Additional vegetation and ground cover information can also be used to improve the estimation of the mean radiant temperature.

Coupling WRF + SOLWEIG = Full Heat Picture

- Following [1], our approach links regional weather dynamics to street-level radiation, producing realistic, time-dependent maps of actual thermal comfort across the whole city.

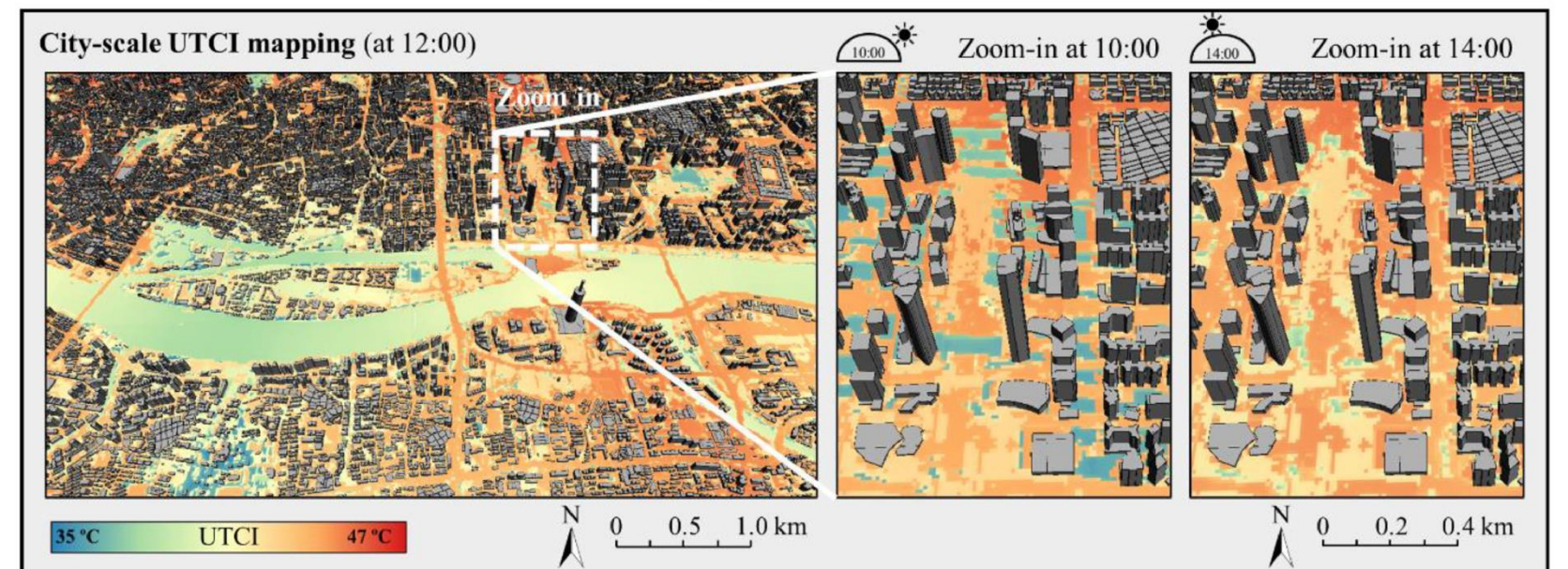
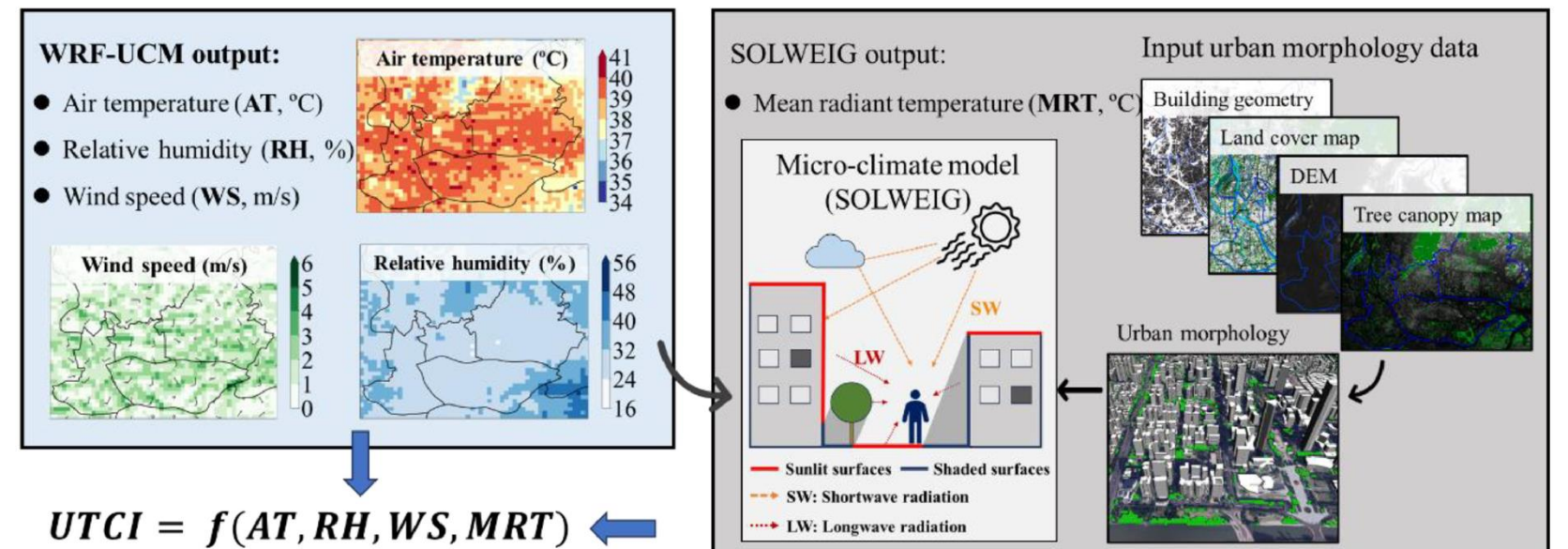
- Why this beats the usual options:
 - **Satellite (land surface temperature):** only shows surface temperature at one moment, with no humidity, wind or diurnal evolution; can be highly inaccurate!
 - **SOLWEIG alone (radiant temperature):** has fine geometric detail but must rely on crude, single-point weather inputs; does not consider neighborhood variations (e.g., sea breeze, see map on last slide)
 - **WRF alone:** captures the heat-island at ~1 km but cannot represent façade shading or tree cooling, so it misses hyper-local details.

WRF-UCM-SOLWEIG framework

Mesoscale urban climate simulation

Micro-climate simulation

← Model input
← Model output



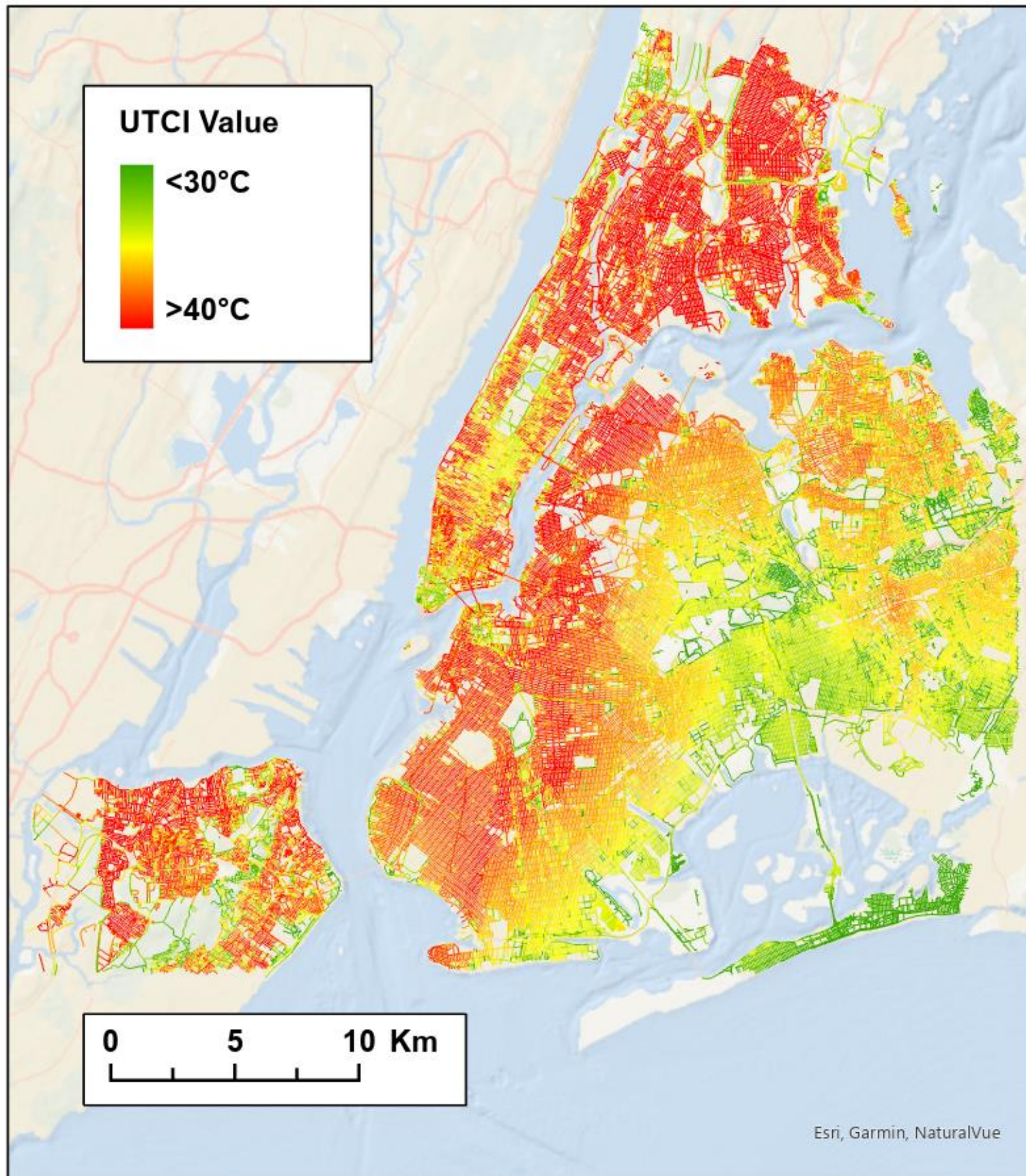
[1] Ding, Zhao, Strebel, Fan, Ge & Carmeliet, *Sustainable Cities and Society*, 112, 2024, 105628.



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Coupling WRF + SOLWEIG = Full Heat Picture

Key takeaway: When we couple WRF's background climate with SOLWEIG's street-level radiation engine, we capture both regional weather and local shading effects, providing a far more realistic assessment of outdoor heat stress in NYC's public spaces.



(UTCI values on street segments)



Thank you!

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