



Metropolitan Water Reclamation District of Greater Chicago

**Welcome to the January
Edition of the 2024 M&R
Seminar Series**

NOTES FOR SEMINAR ATTENDEES

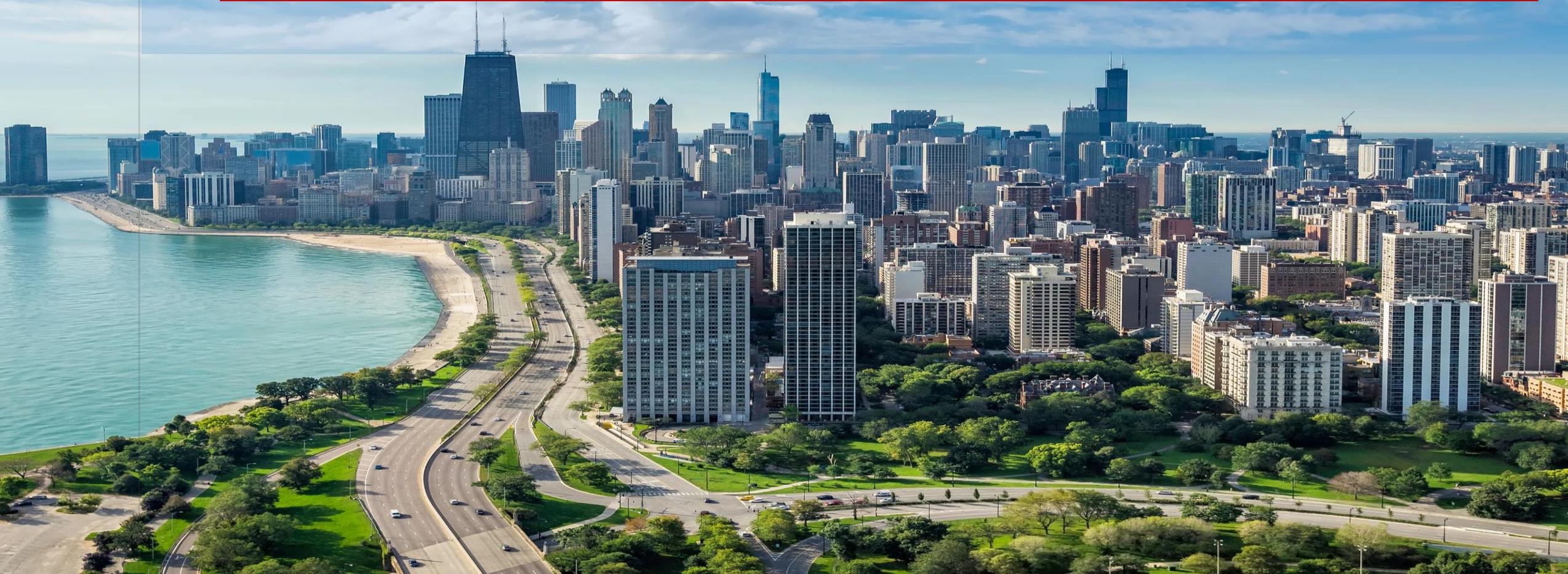
- Remote attendees' audio lines have been muted to minimize background noise. **For attendees in the auditorium, please silence your phones.**
- A question and answer session will follow the presentation.
- For remote attendees, please use the "**Chat**" feature to ask a question via text to "**Host.**" **For attendees in the auditorium, please raise your hand and wait for the microphone to ask a verbal question.**
- The presentation slides will be posted on the MWRD website after the seminar.
- This seminar is pending approval by the ISPE for one PDH and has been approved by the IEPA for one TCH. Certificates will only be issued to participants who attend the entire presentation.

Ashish Sharma, Ph.D.
Adjunct Professor/Climate and Urban Sustainability Lead,
Department of Atmospheric Sciences, University of Illinois
Urbana-Champaign, Illinois



In addition to faculty positions at UIUC, Dr. Sharma holds a joint appointment as a Climate Scientist at Argonne National Laboratory. He received a Bachelor's degree in Electronics and Communication Engineering from Jaypee University of Information Technology, a Master of Science and Ph.D. in Aerospace Engineering from Arizona State University. Dr. Sharma has expertise in atmospheric sciences, focusing on regional climate, air quality, and assessing adaptation and mitigation strategies. Through collaborative research across science, engineering, social sciences, and policy, he studies environmental justice issues including heat, fog, air quality, and high-impact weather. He is a fellow of the Royal Meteorological Society. He serves on the Trust for Public Land's Natural Solutions Tool advisory committee (2022). As a co-author of the first climate action plan for the Chicago metro region (2021), he has received numerous awards, including the American Planning Association Merit in Sustainability Award (2022) and the Center for Climate and Energy Solutions Climate Leadership Award (2021).

CLIMATE SCIENCE TO ACTIONABLE URBAN SOLUTIONS



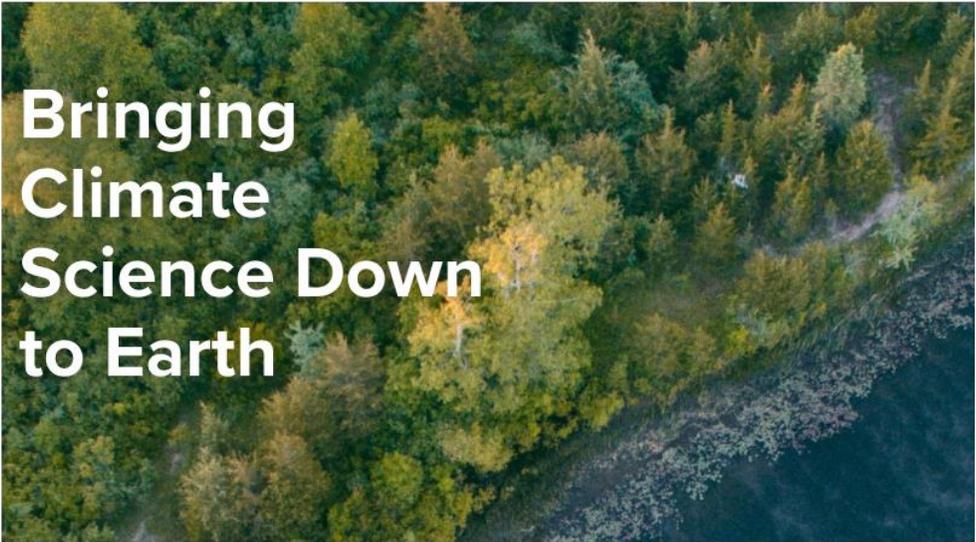
Ashish Sharma

Climate and Urban Sustainability Lead, DPI
Dept. of Atmospheric Sciences, UIUC
University of Illinois System
sharmaa@uillinois.edu



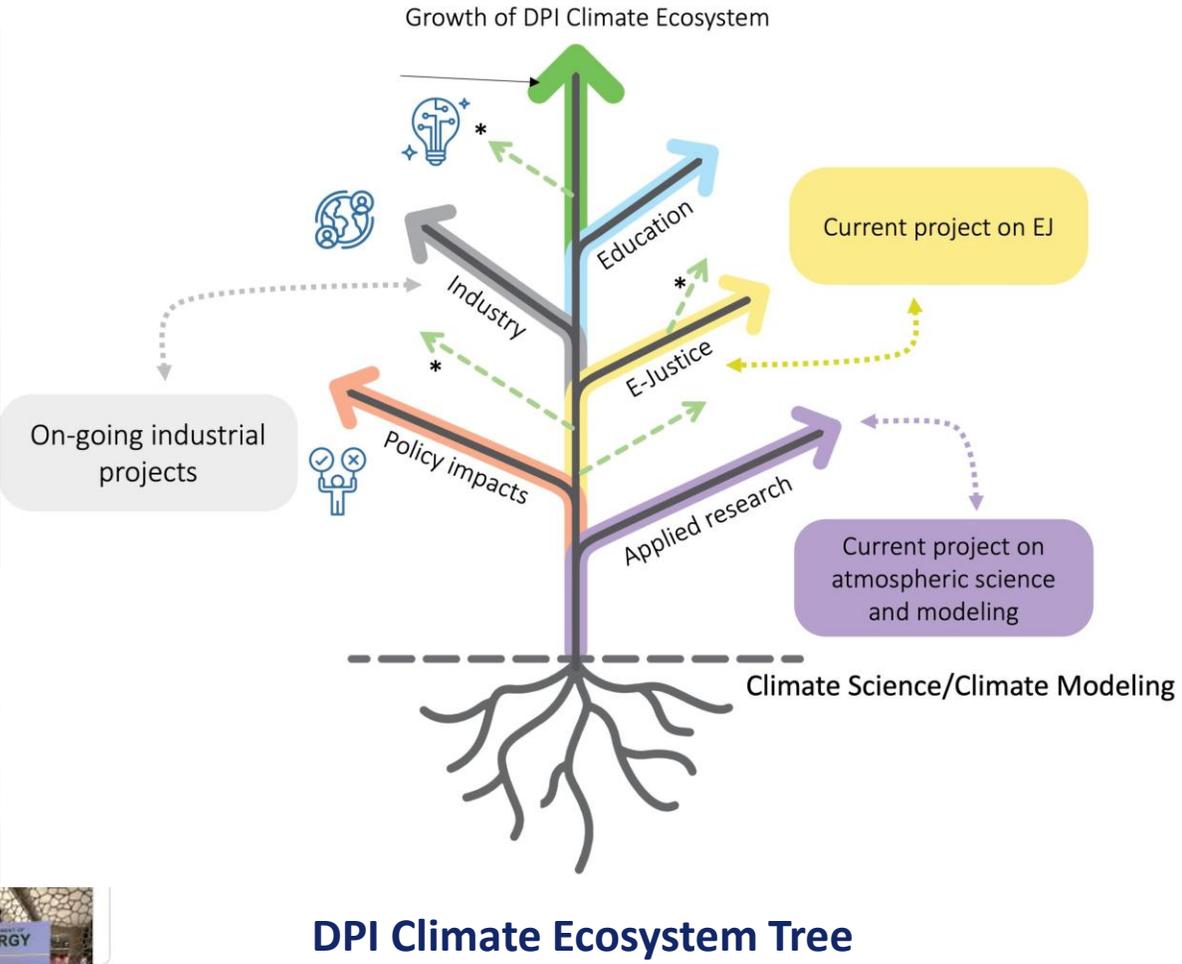
U.S. DEPARTMENT OF
ENERGY





Working with federal agencies, industry and academic partners to build a climate intelligence ecosystem that translates state-of-the-art climate science to provide focused solutions and services and update critical policies to guide climate-resilient decisions

- What we do**
- Basic and applied research
 - Climate consulting practice
 - Empower climate-resilient communities
 - Environmental policy



The Need for Urban-Resolving Climate Modeling Across Scales

Ashish Sharma , Donald J. Wuebbles , Rao Kotamarthi

First published: 26 January 2021 | <https://doi.org/10.1029/2020AV000271> | Citations: 1

Studying via multiple lens!

Framework for Integrated Urban Research



- Drivers of Change
- Climate change
 - Economic development
 - Population dynamics and mobility
 - Urbanization
 - Governance, equity (\$, opportunity) and health
 - Emerging technologies (autonomous vehicles, AI-assisted learning, etc.)

- Critical Issues / Research Strategies
- Effects of urban systems on climate at different scales
 - High resolution climate models
 - Representation of cities in climate model
 - Scale-resolving urban land cover and urban processes
 - Future evolution of the urban landscape
 - Observations: data & analysis

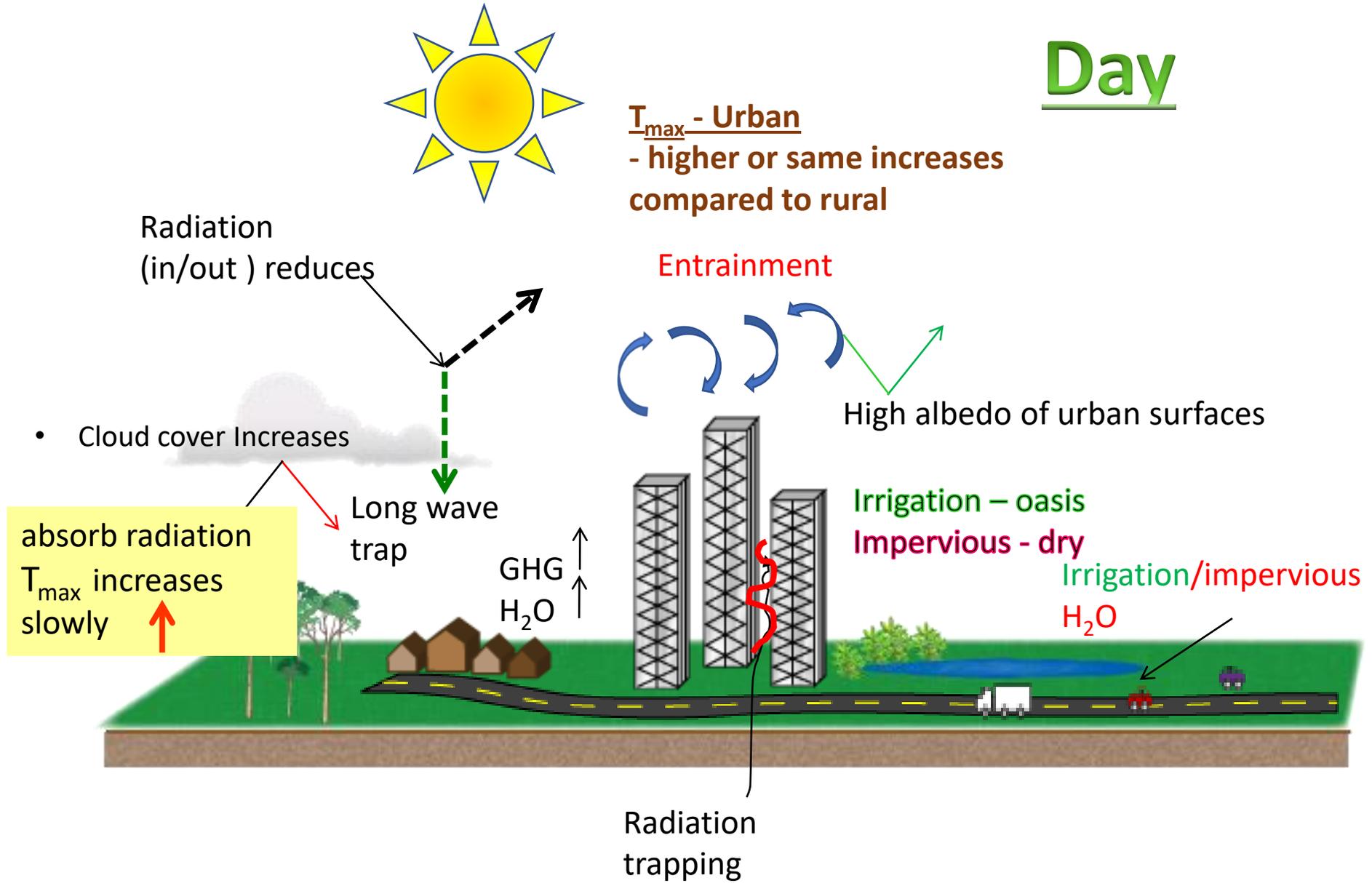
- Critical Considerations
- Irreversibility of potential impacts
 - Adaptive capacity of sectors and urban assets
 - New science and analyses to evaluate interactions among natural, engineered, and social and behavioral urban subsystems

- Critical Evaluations
- Viability / co-benefits / trade-offs in evaluating outcomes
 - Effects on social systems and equity (\$, opportunity, health, ...)
 - Effects on finance and governance
 - Effects on natural resources

Urban climate research capabilities

- **Bridging urban scales: multiscale modeling**
 - global \longleftrightarrow regional \longleftrightarrow local \longleftrightarrow hyper-local
 - heat islands, lake breeze, heat waves, air quality
- **Numerical modeling**
 - data assimilation, subgrid variability
- **Urban meteorology + AQ forecasting**
- **Urban adaptation and mitigation strategies**
 - green, cool, and photovoltaic roofs
 - energy consumption, vulnerability analysis
 - nature-based solutions for heat, air quality, and flooding
- **Urban climate action plans + policies + transdisciplinary research**
- **Other focus areas...**
 - urban climate + crime; machine learning

Day



T_{max} - Urban
- higher or same increases
compared to rural

Entrainment

High albedo of urban surfaces

- Cloud cover Increases

absorb radiation
 T_{max} increases slowly
↑

Long wave trap
GHG
 H_2O

Irrigation - oasis
Impervious - dry
Irrigation/impervious
 H_2O

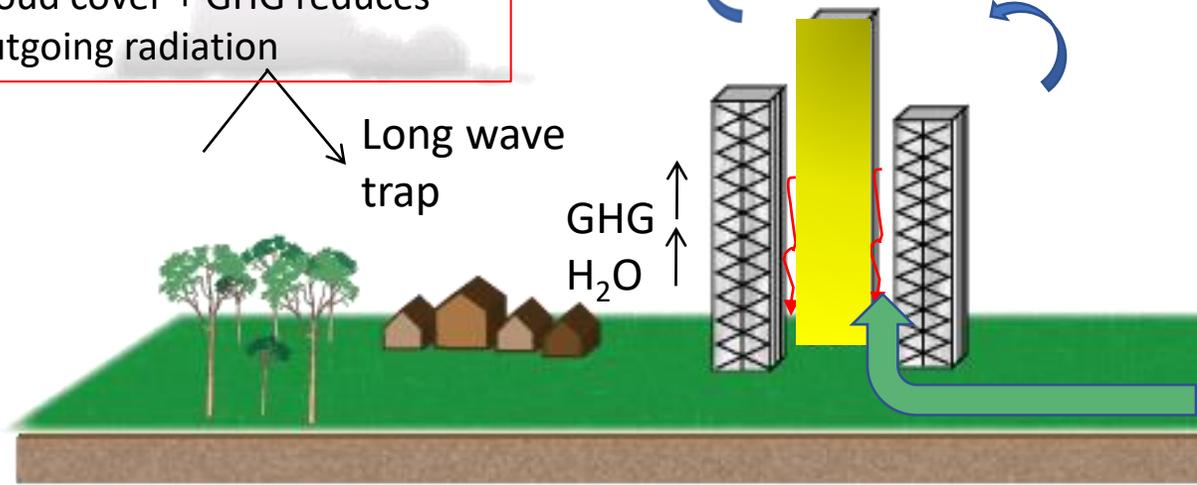
Radiation trapping



- Significant increase of T_{min} (compared to rural)
- reduction of DTR is larger
- UHI at night is amplified

T_{min} increases faster than T_{max}

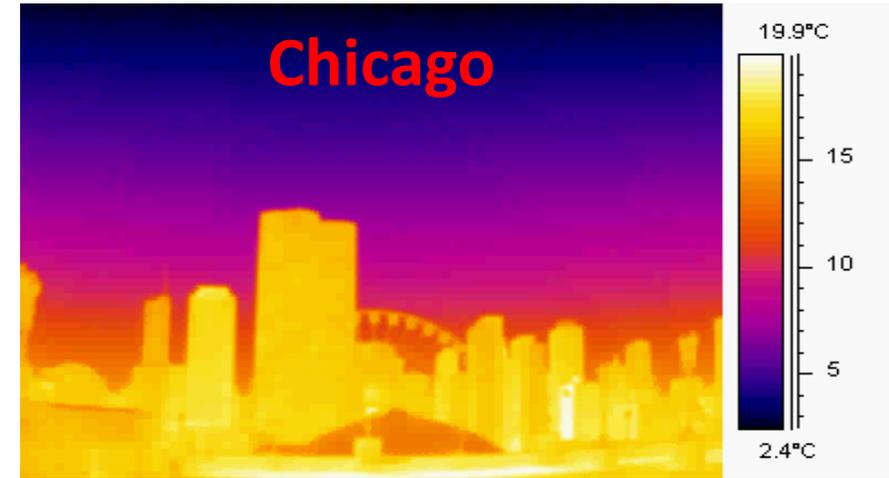
• Cloud cover + GHG reduces outgoing radiation



Night

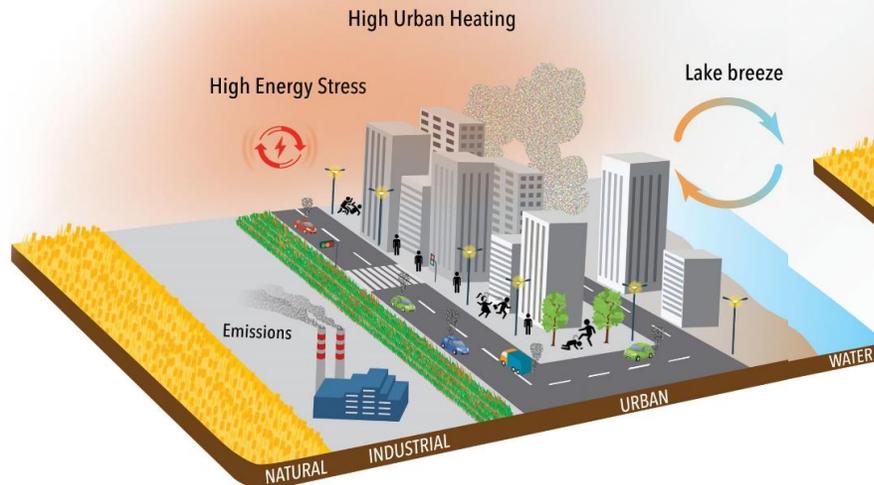
Urban systems

Flooding **Heat** Housing Marginalization Health
 Stress **Food security** Extremes **Tornadoes**
 Gentrification **Jobs** **Green spaces** Deterioration
 Variability

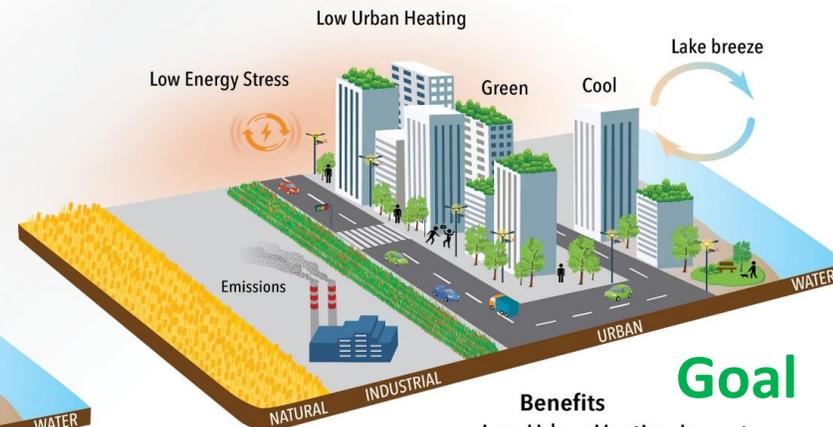


Current Urban Environment

Stressed

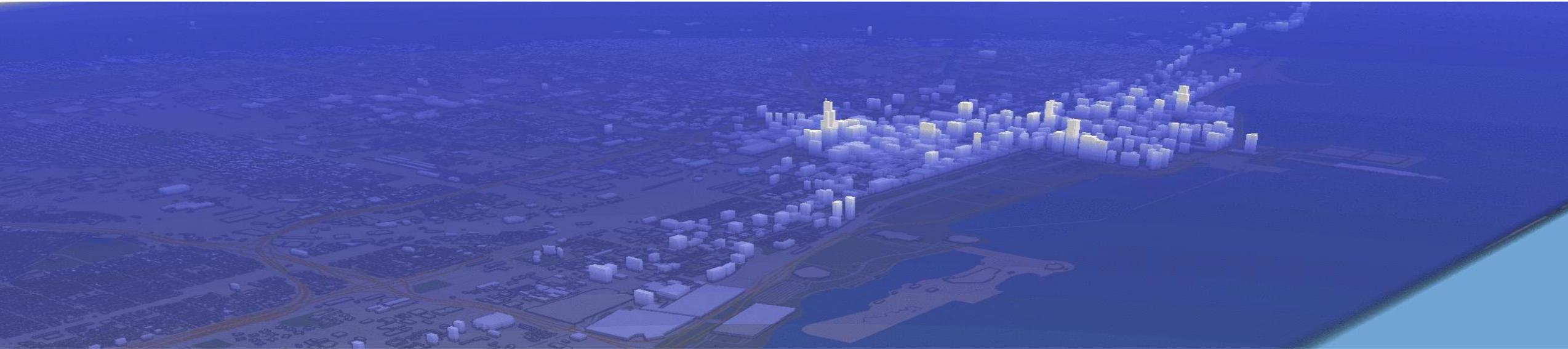


Resilient Urban Environment with Adaptive Choices



- Goal**
- Benefits**
- Low Urban Heating Impacts
 - Reduced Energy Consumptions

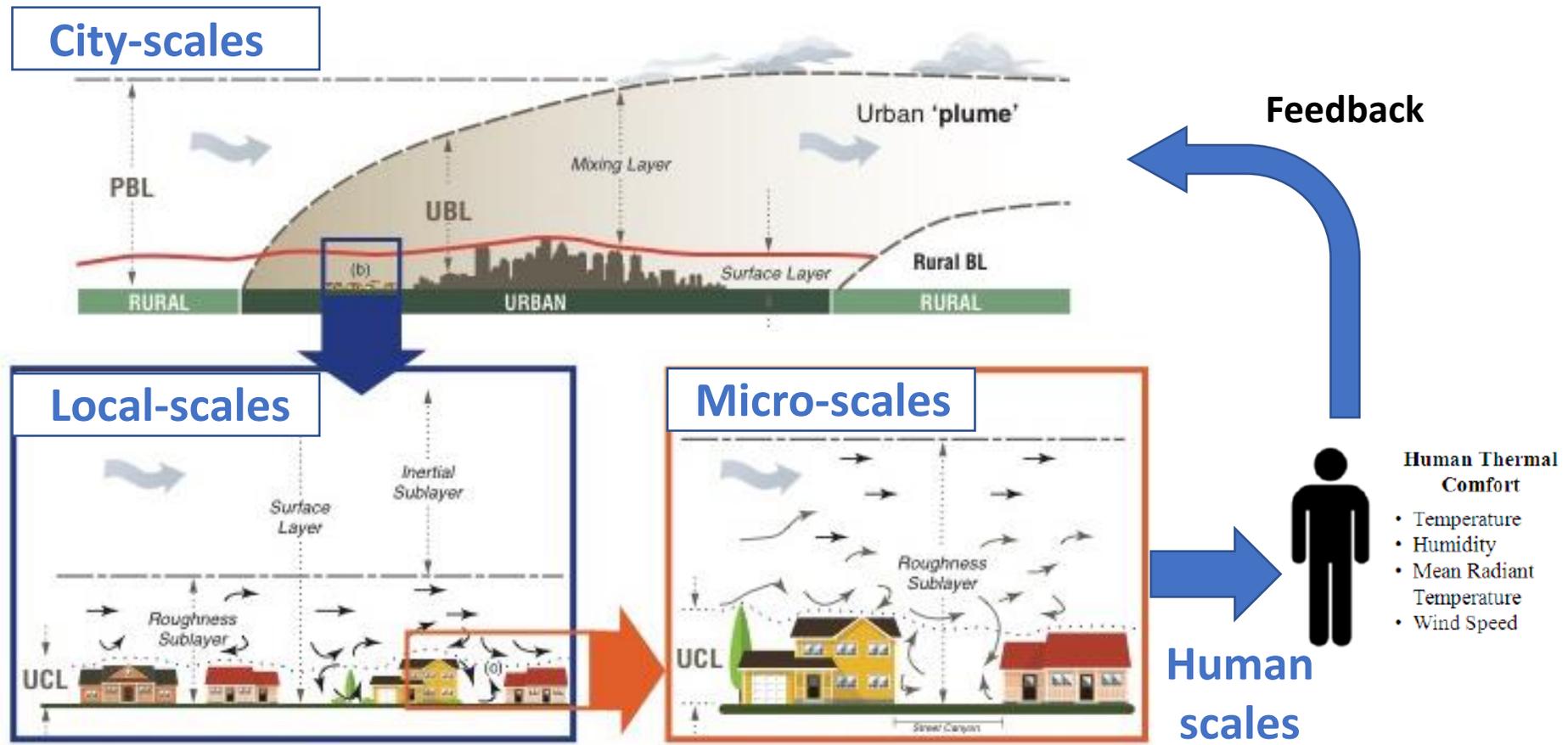
Urban systems: Multiscale, interdependent, social, natural and engineered complex systems.



Visualization: Miranda and Sharma

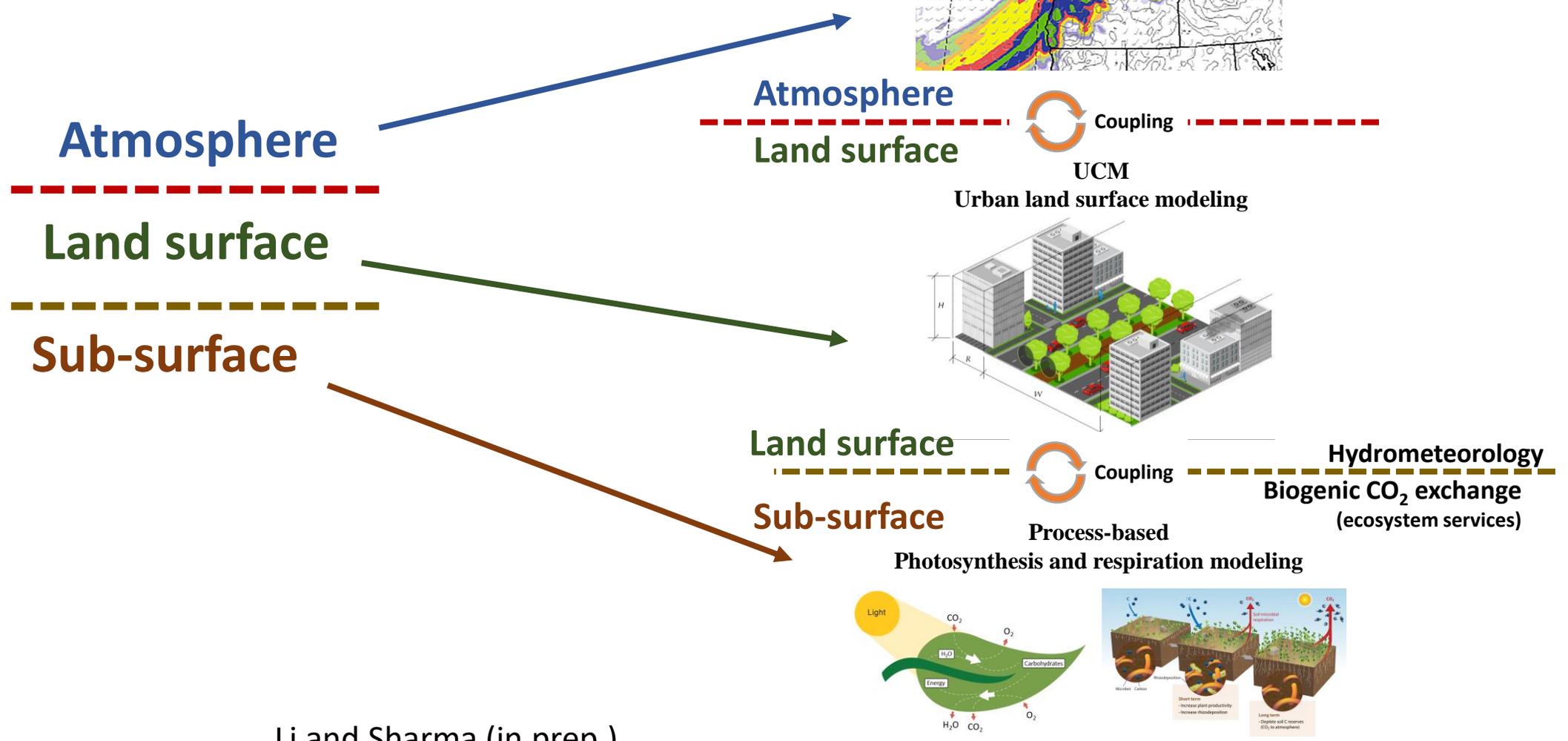
- Improvements in urban boundary layer processes.
- Fundamental and translational research that uses **science to serve the society.**

Bridging urban scales



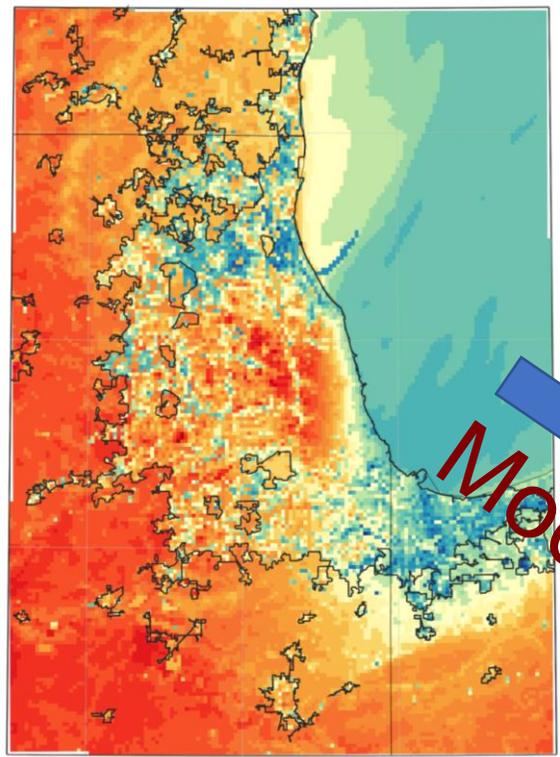
- Need tools with which large- and small- cities will benefit.
- Complicated models to train simplistic models.

Vertical scale interactions in urban areas

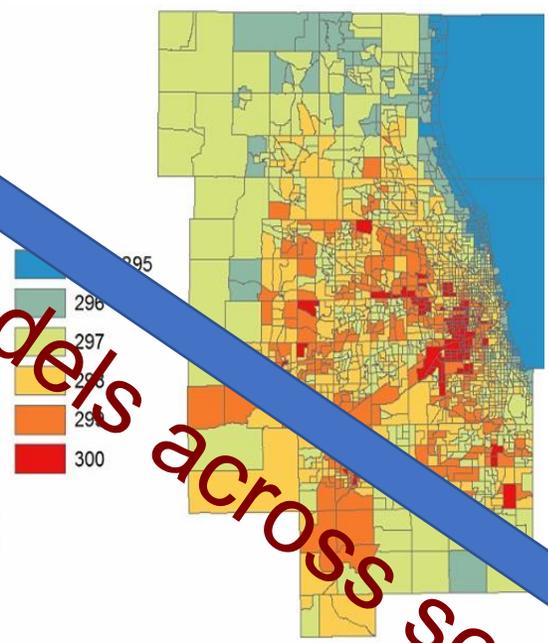


Computer (climate) urban models

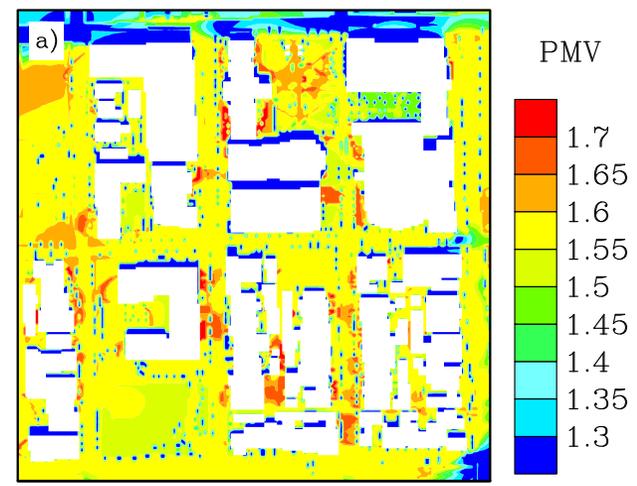
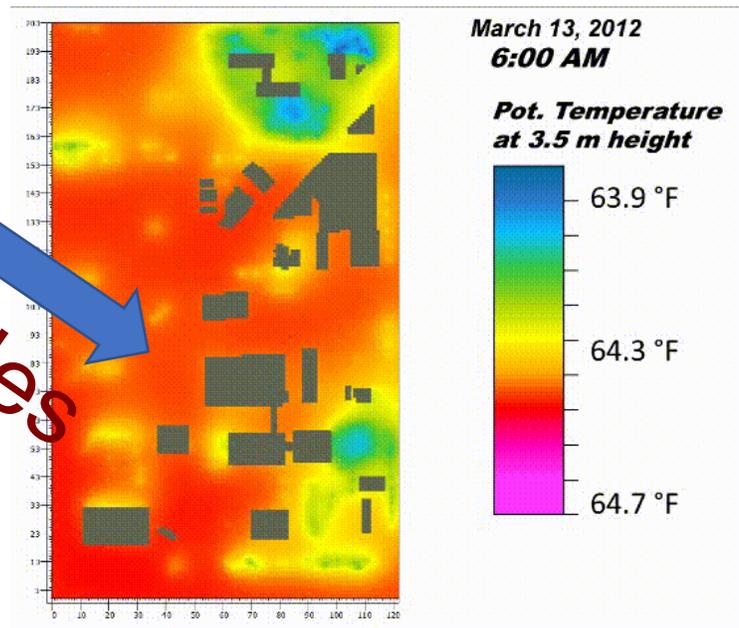
Regional-scale models



City-scale models



Neighborhood models (2 m resolution)



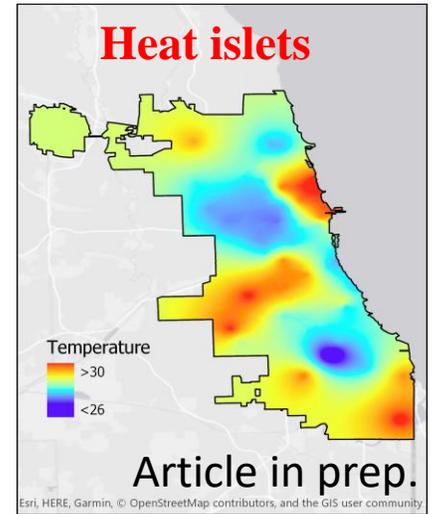
Models across scales

Urban heterogeneity

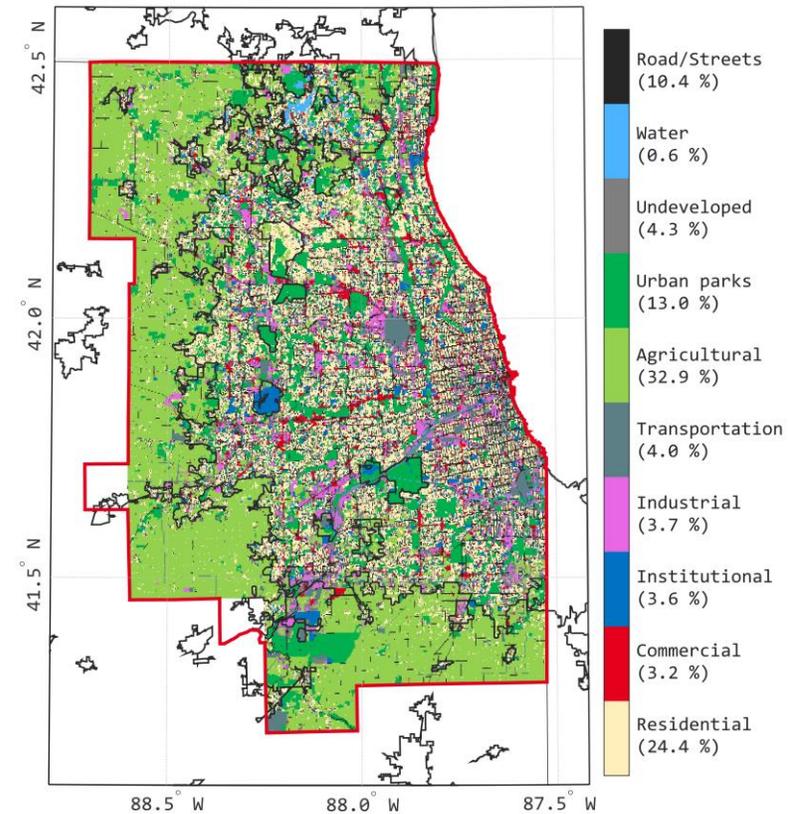
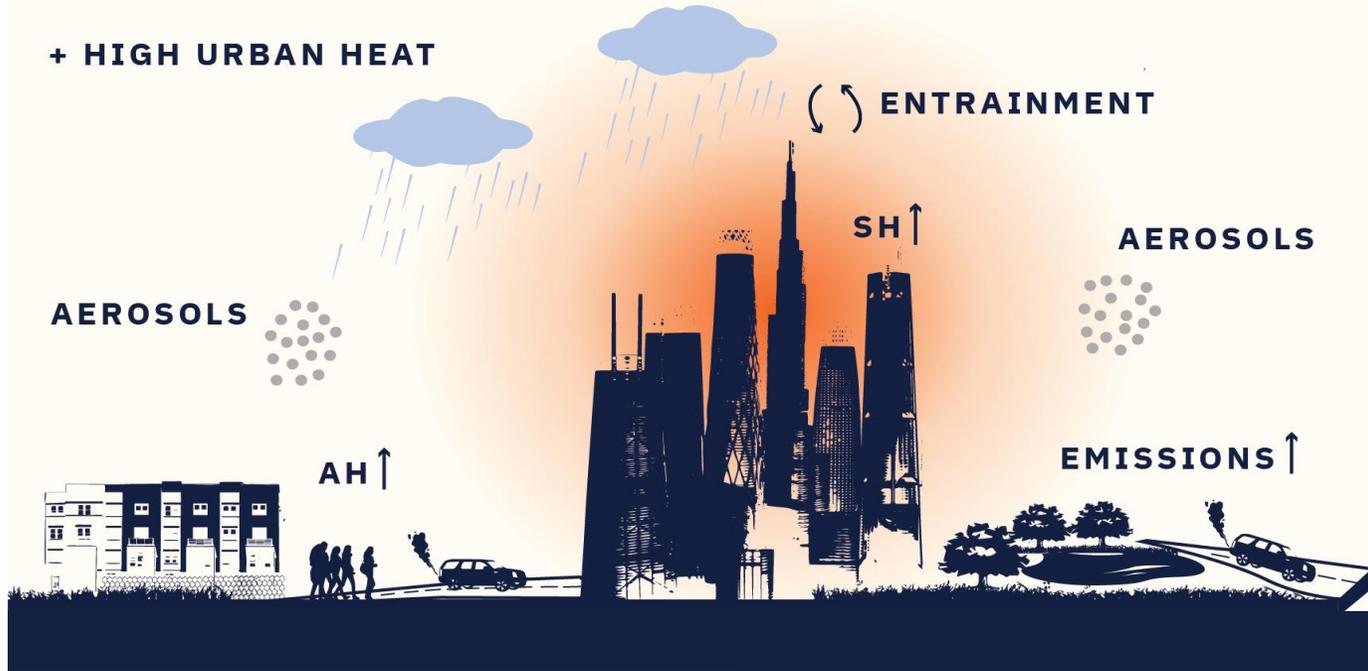
Atmosphere

Land surface

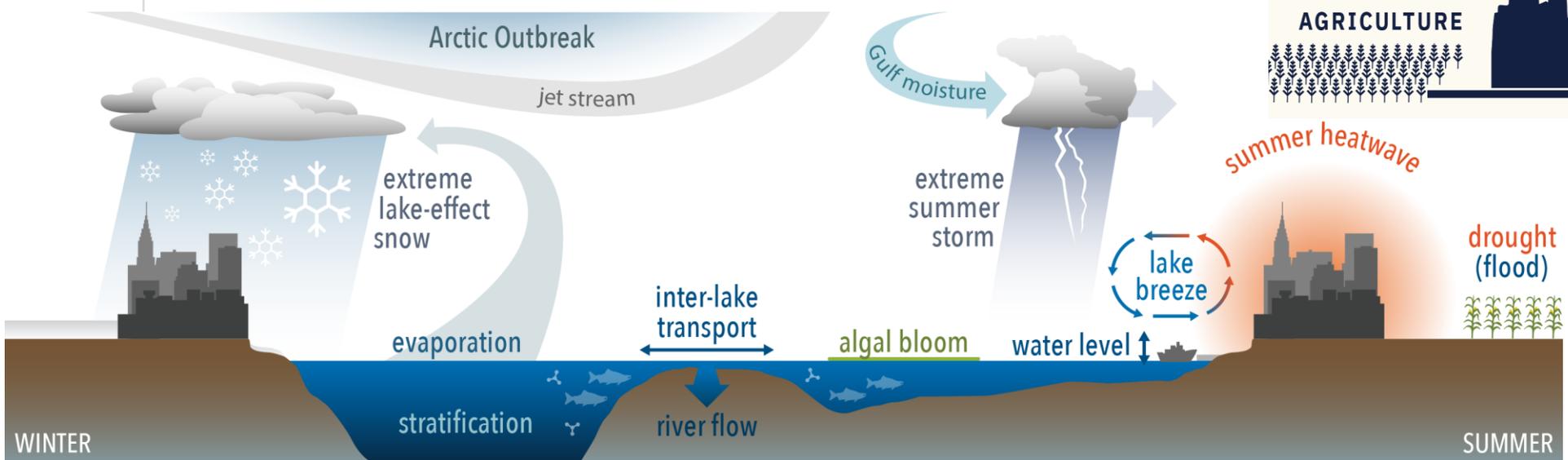
Sub-surface



A. SURFACE-ATMOSPHERE INTERACTIONS



Regional interactions



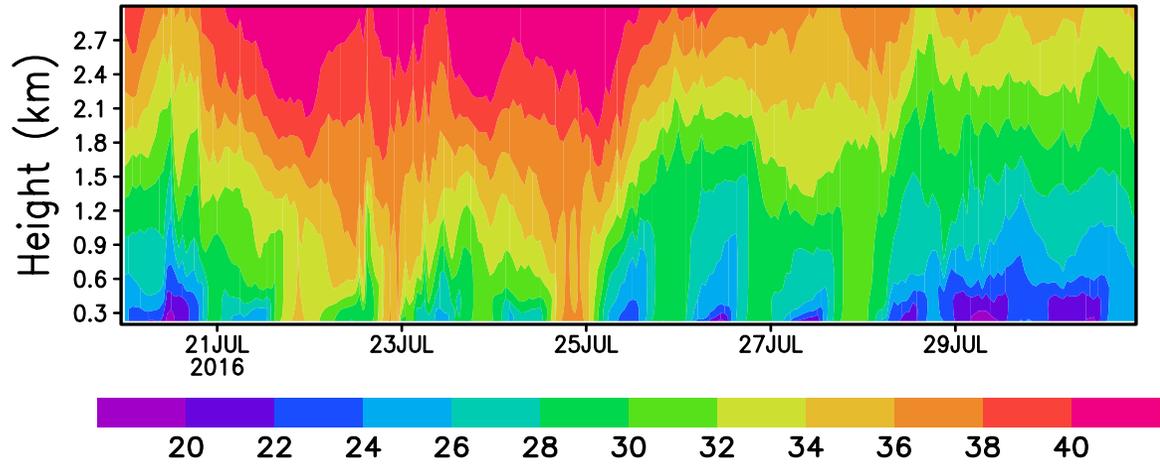
B. LAND SURFACE GRADIENTS



Sharma et al. (2018) *Earth's Future*

Urban heat island + heatwave interactions

Temperature at O'Hare airport

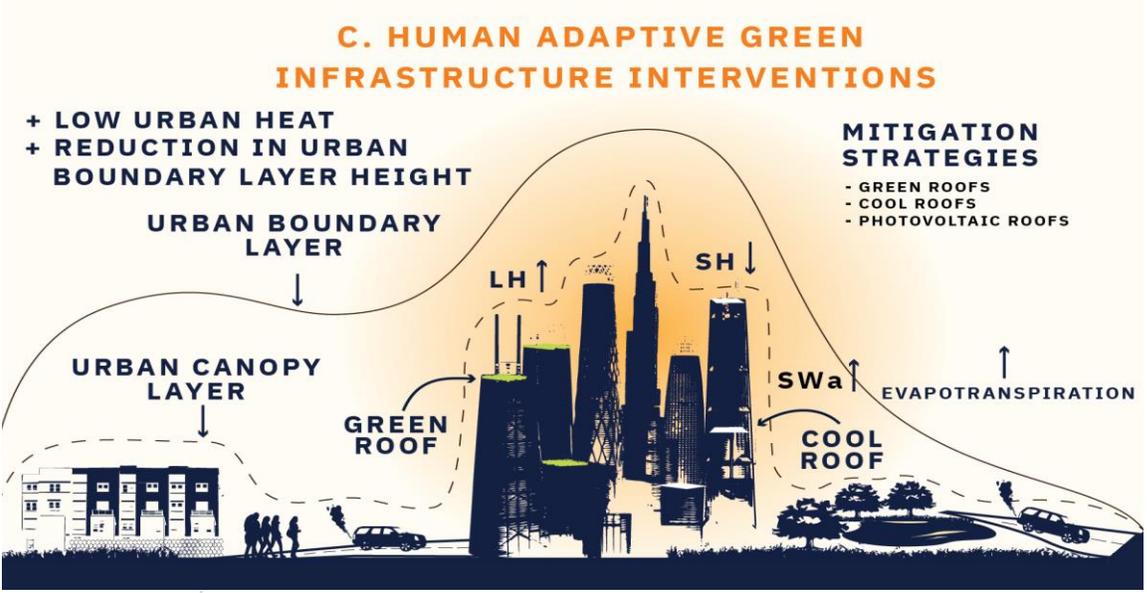


C

Sharma et al. (in prep)

What solutions do we have?

Solutions to mitigate heat and flooding

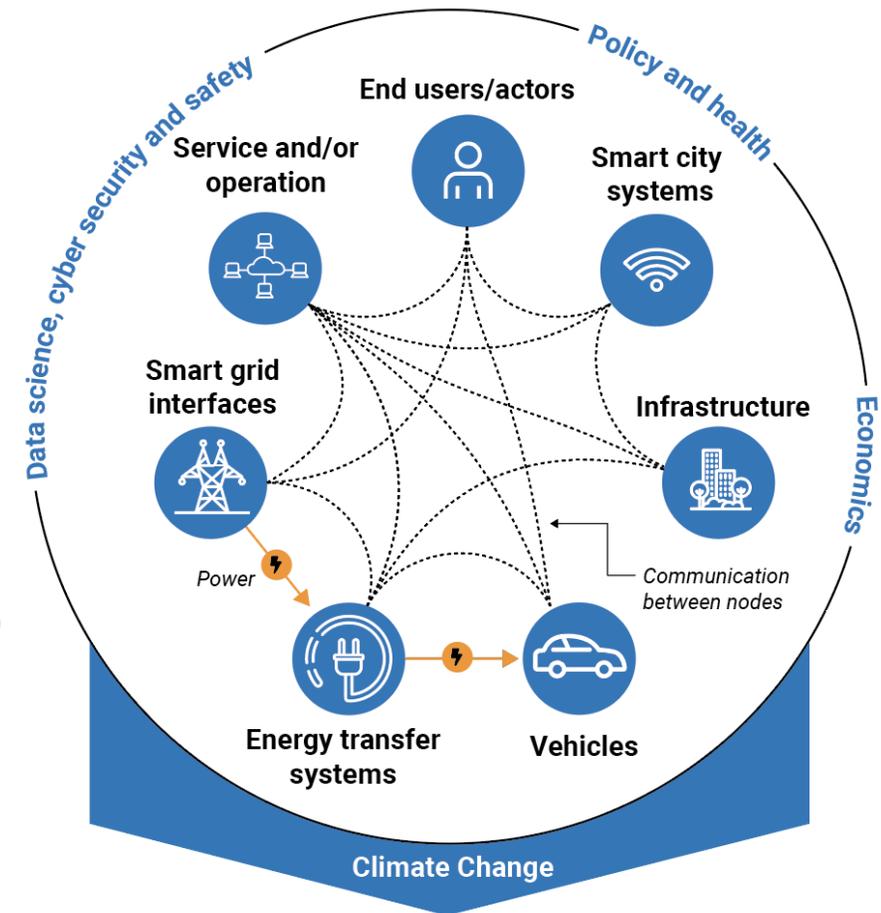


✓ Technological-engineered-ecological mix of urban solutions.

Urban solutions

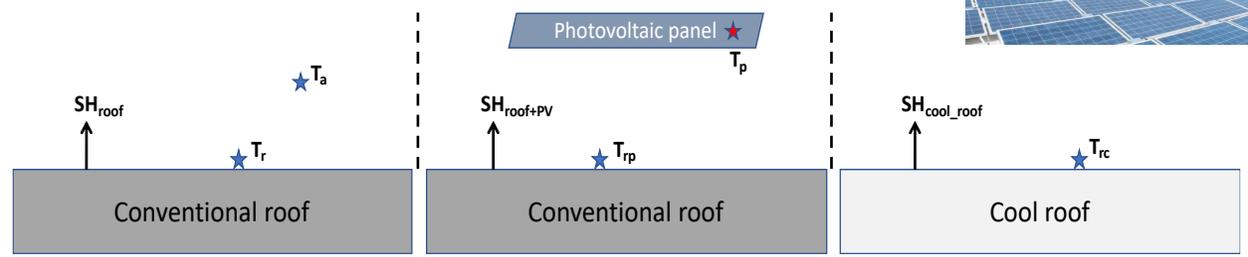
Should benefit the larger urban ecosystem

- Investing in cleaner energy sources
- Nature-based solutions
- Decarbonize energy & transportation sector and promoting public transportation
- Enforcing regulations on emissions from industries and vehicles
- Nature-based solutions (heat + air quality + flooding)
- Improved urban planning + urban design (urban landscape)

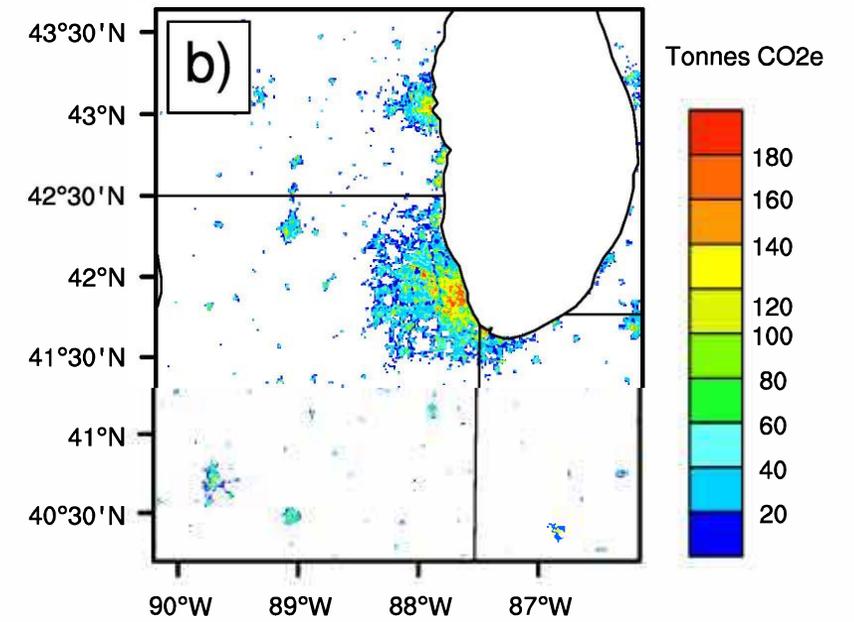


Let's look at a few of these solutions and how different tools can help us make decisions!

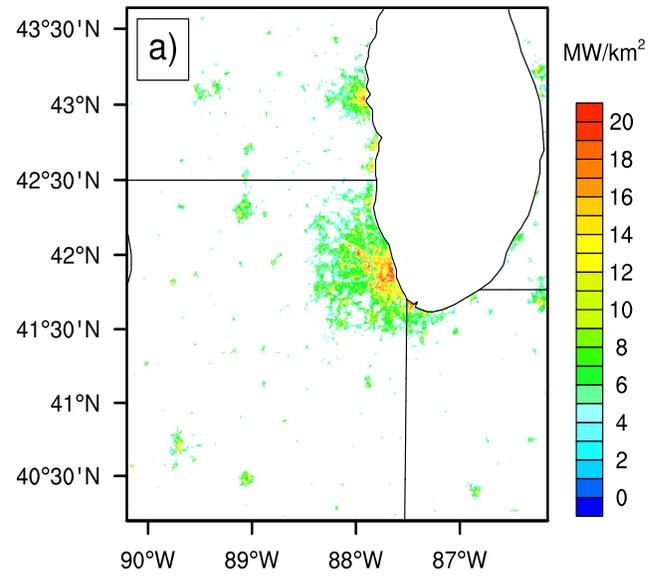
Photovoltaic roofs



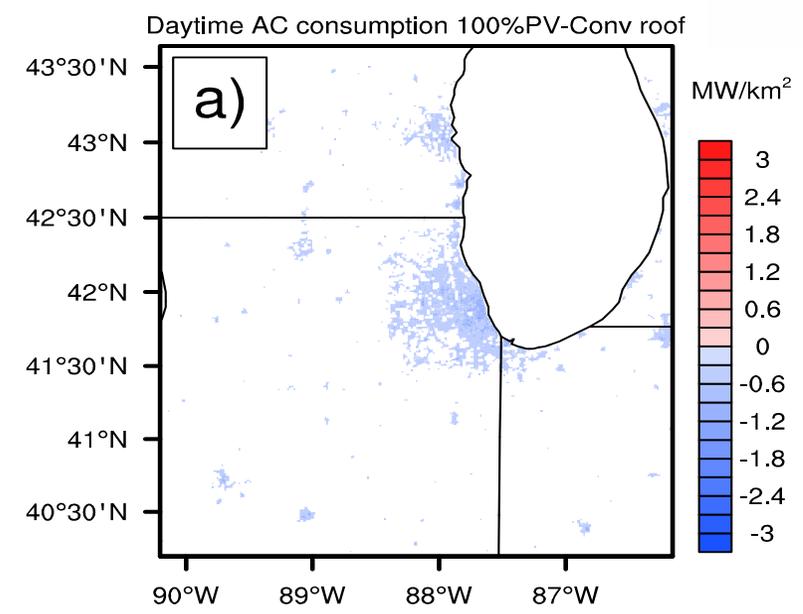
Photovoltaic CO₂ emissions offset



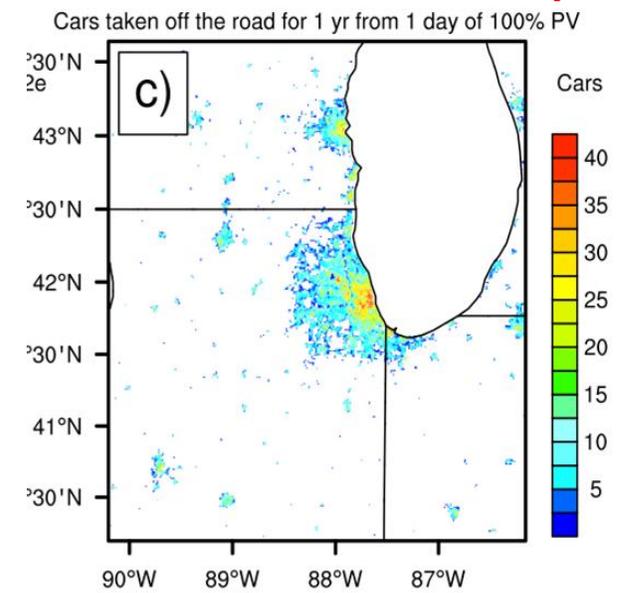
Rooftop photovoltaic production potential



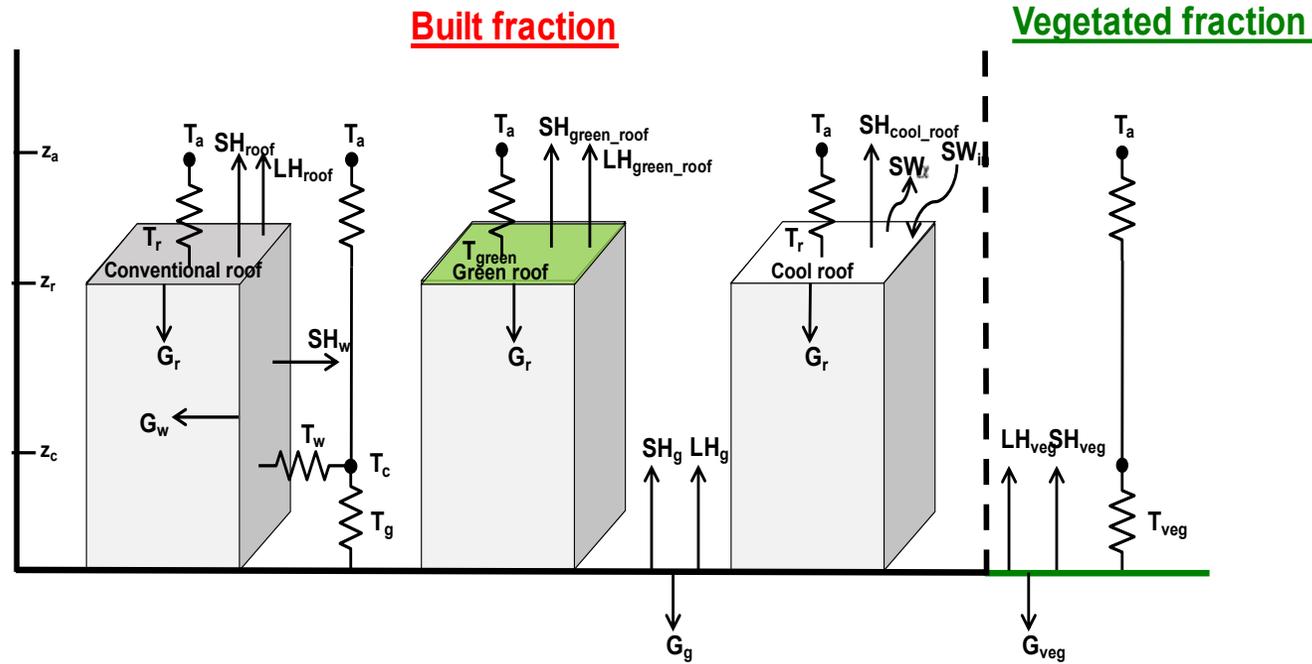
AC consumption Photovoltaic - conventional



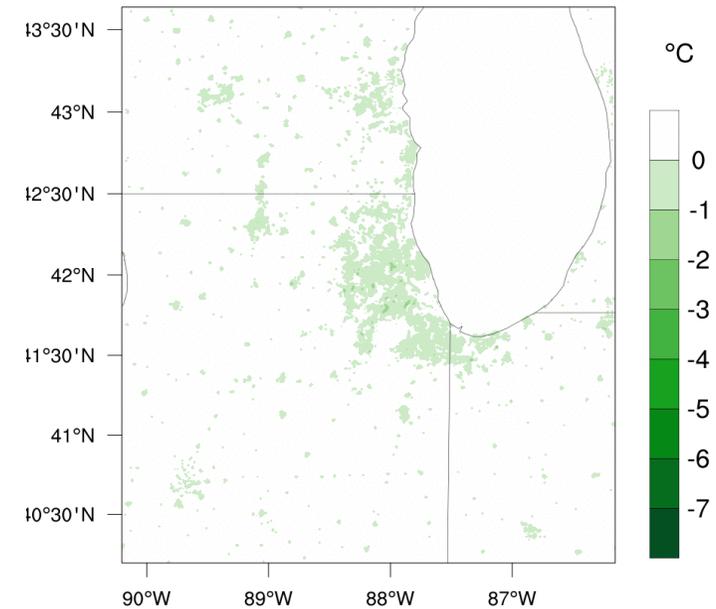
Cars off the road for 1 day



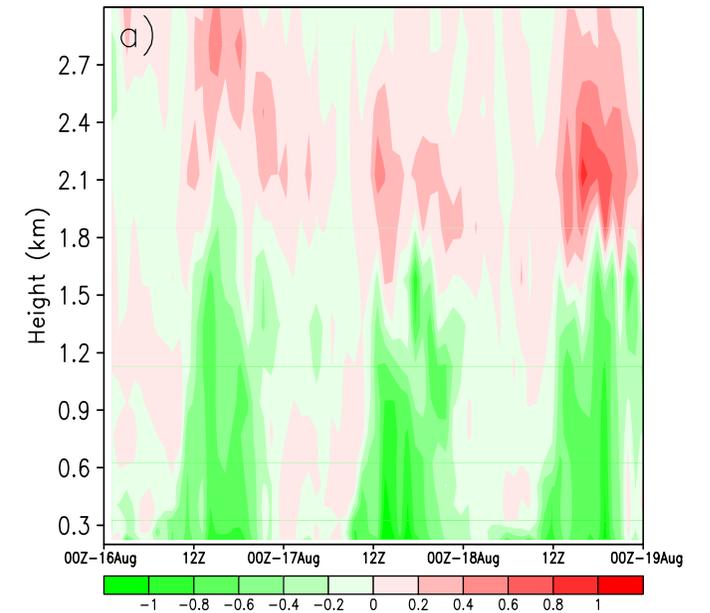
Green/cool roofs



Green roof temperature

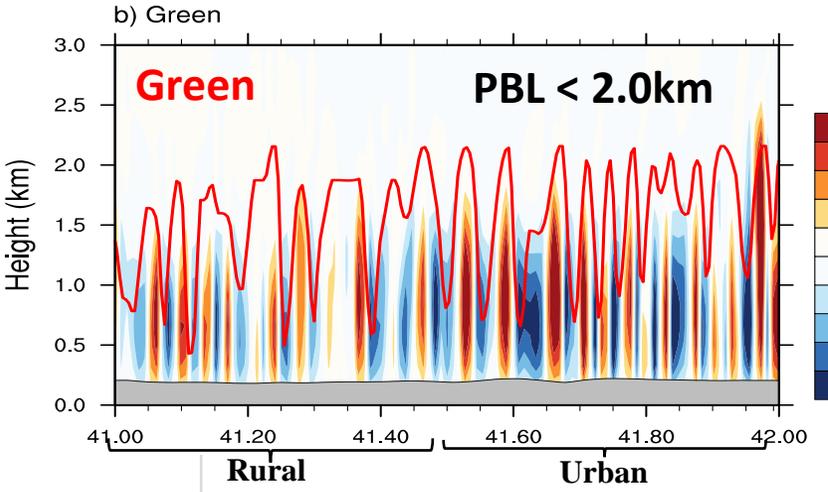
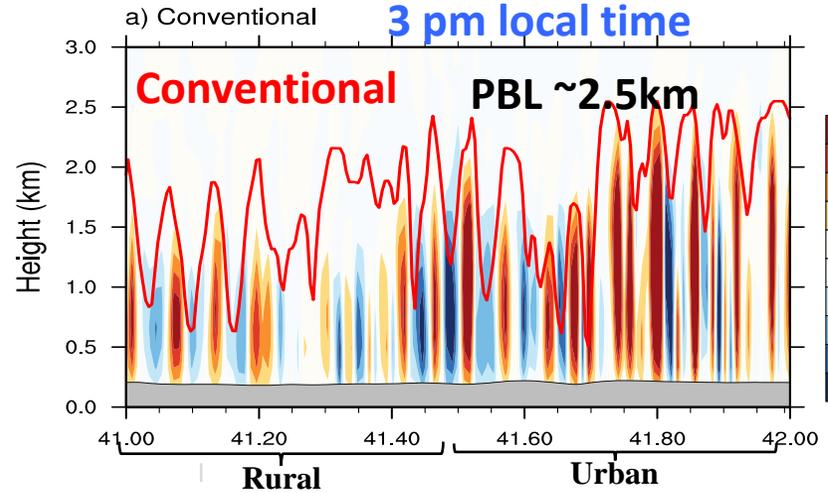
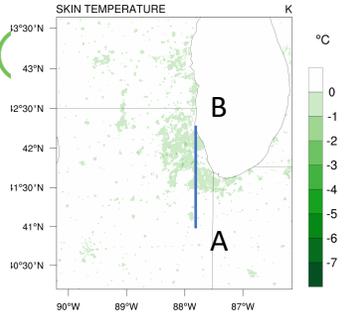


T (Green-Conventional)

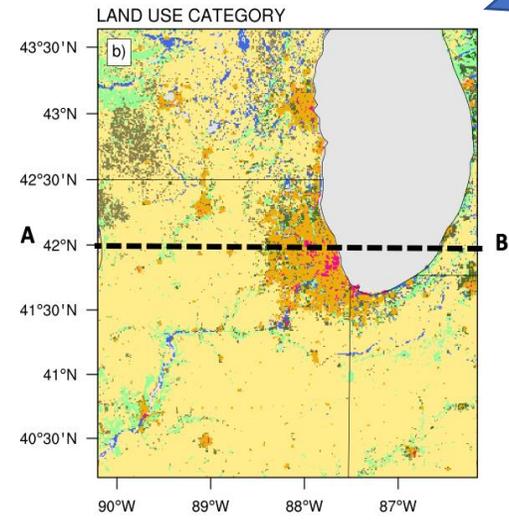


Rooftop solutions: Transport OR photochemical processes

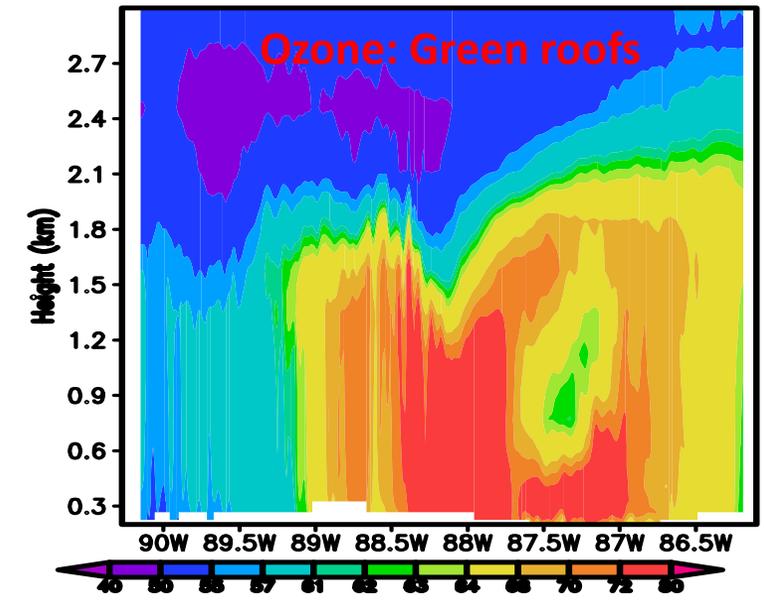
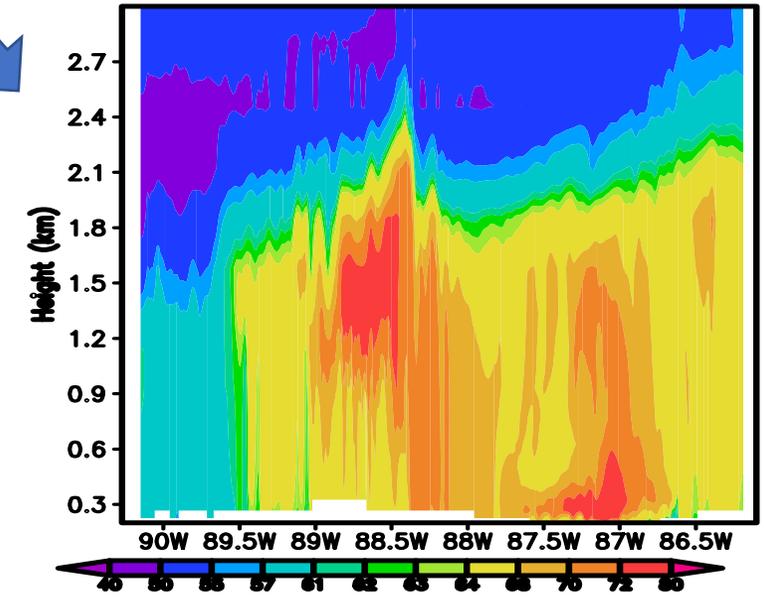
— Which are dominant?



reduced convection and thinner updrafts



Ozone: Conventional roofs

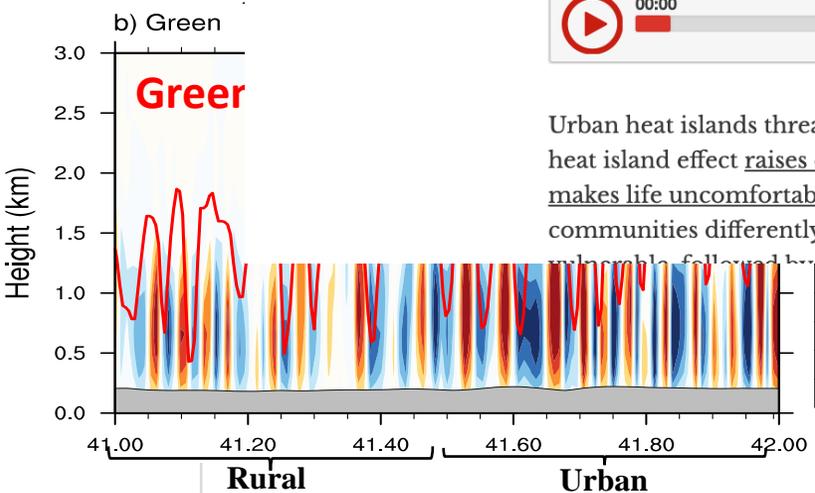
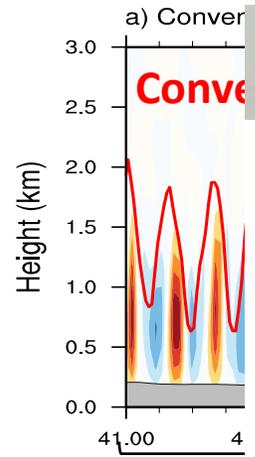
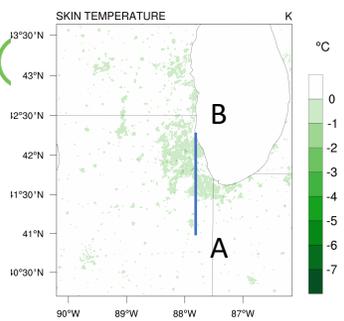


Rooftop solutions: Transport OR photochemical processes

— Which are dominant?

Ozone: Conventional roofs

Green and cool roofs provide relief for hot cities, but should be sited carefully



June 30, 2016 5:49am EDT

Reflective roof and skylights on a Walmart store, Las Vegas, NV. Walmart/Flickr, CC BY

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- Facebook 329
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- Print

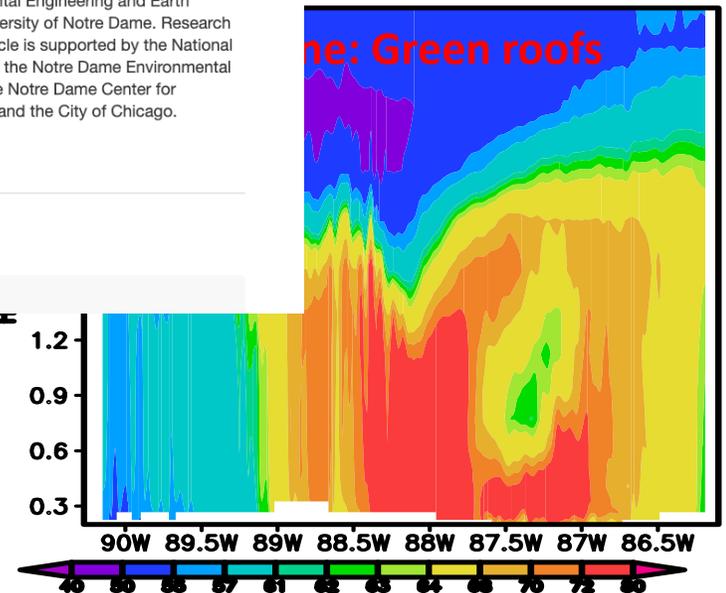
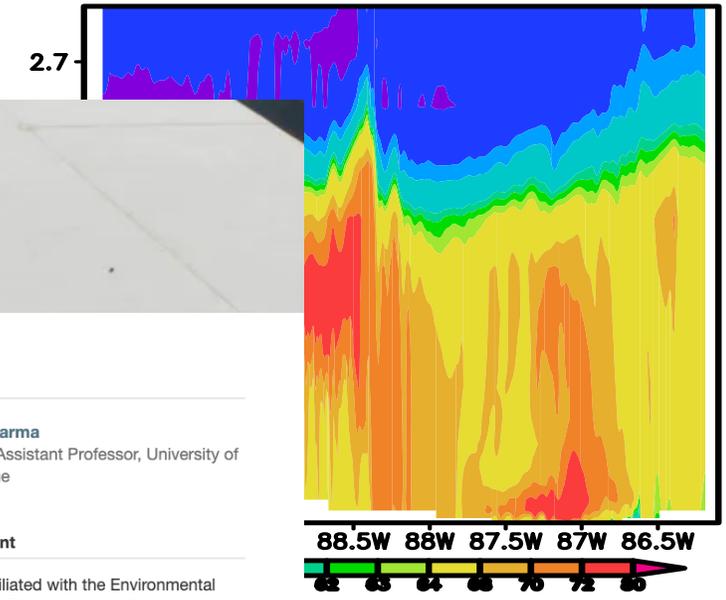
More than half of the world's population lives in cities, and the [United Nations](#) projects that this share will rise to 70 percent by 2050. During the daytime, these expanding urban areas absorb more solar energy than the surrounding countryside. At night they radiate the heat back to the atmosphere. Higher temperatures in cities compared to the areas around them create what are known as urban heat islands (UHIs).

Listen
Beyond Zero Radio podcast interview with Dr. Sharma
00:00 / 29:17

Download
MP3 / 13 MB

Urban heat islands threaten urban sustainability and public health in cities. The heat island effect raises death rates, increases energy demand for cooling, and makes life uncomfortable even for healthy residents. It affects various communities differently: poor and elderly residents and small children are most vulnerable, followed by people who live in highly industrialized areas.

- ✓ One solution can't fit all.
- ✓ Need a mix of solutions.



Author

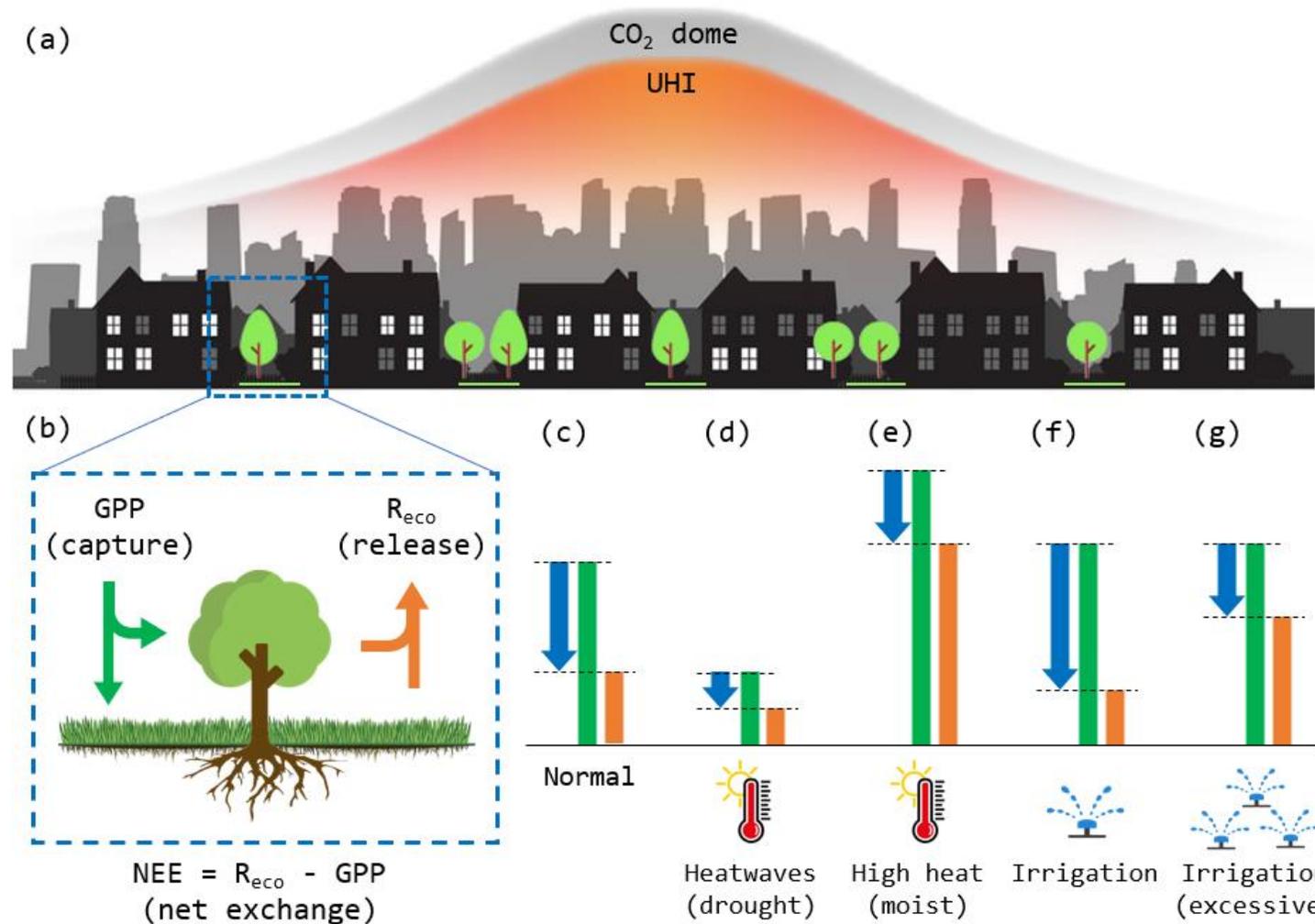
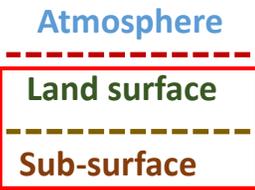
Ashish Sharma
Research Assistant Professor, University of Notre Dame

Disclosure statement
Ashish Sharma is affiliated with the Environmental Change Initiative, ND Energy and the Department of Civil and Environmental Engineering and Earth Sciences at the University of Notre Dame. Research described in this article is supported by the National Science Foundation, the Notre Dame Environmental Change Initiative, the Notre Dame Center for Sustainable Energy, and the City of Chicago.

Partners
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creative commons

Urban vegetation – trees, urban parks forests, etc.



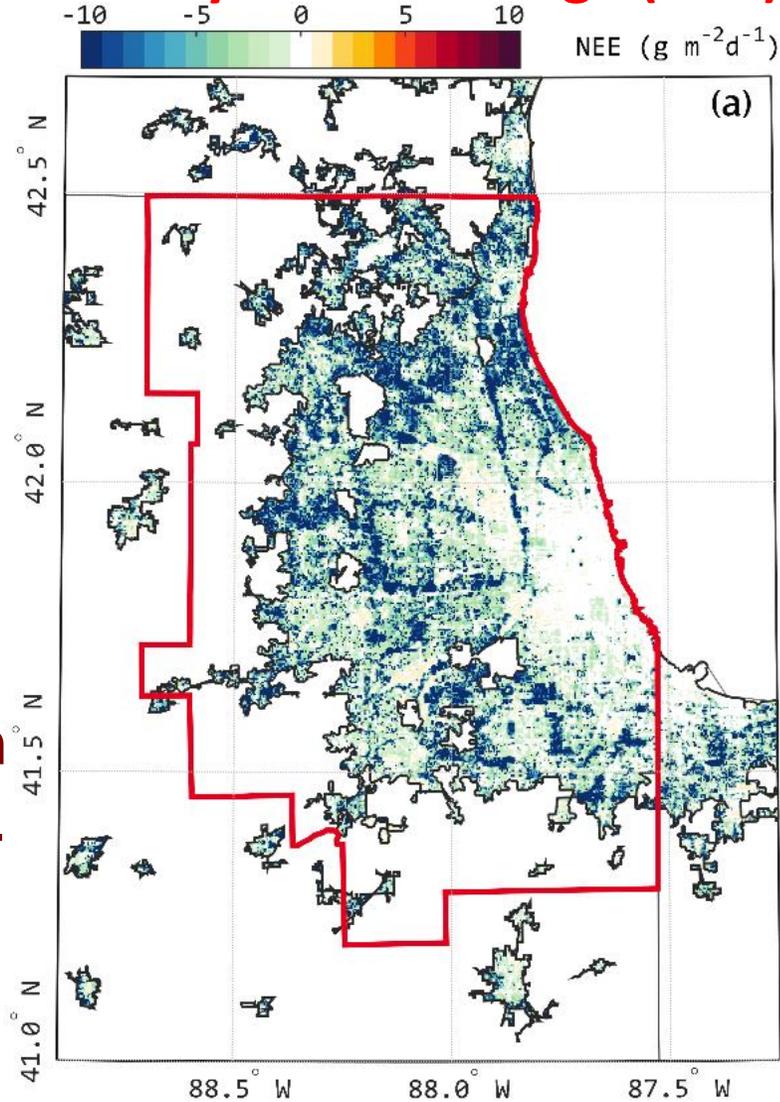
Carbon exchange in urban areas

- Passive impacts from heat and elevated background CO₂ level alter growth of plants.

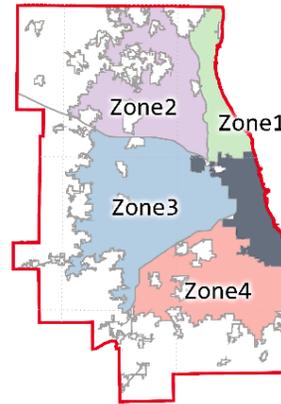
Changes in CO₂ due to urban vegetation

- High spatial variability
- Active CO₂ sequestration in urban parks, followed by vegetated land in residential areas.

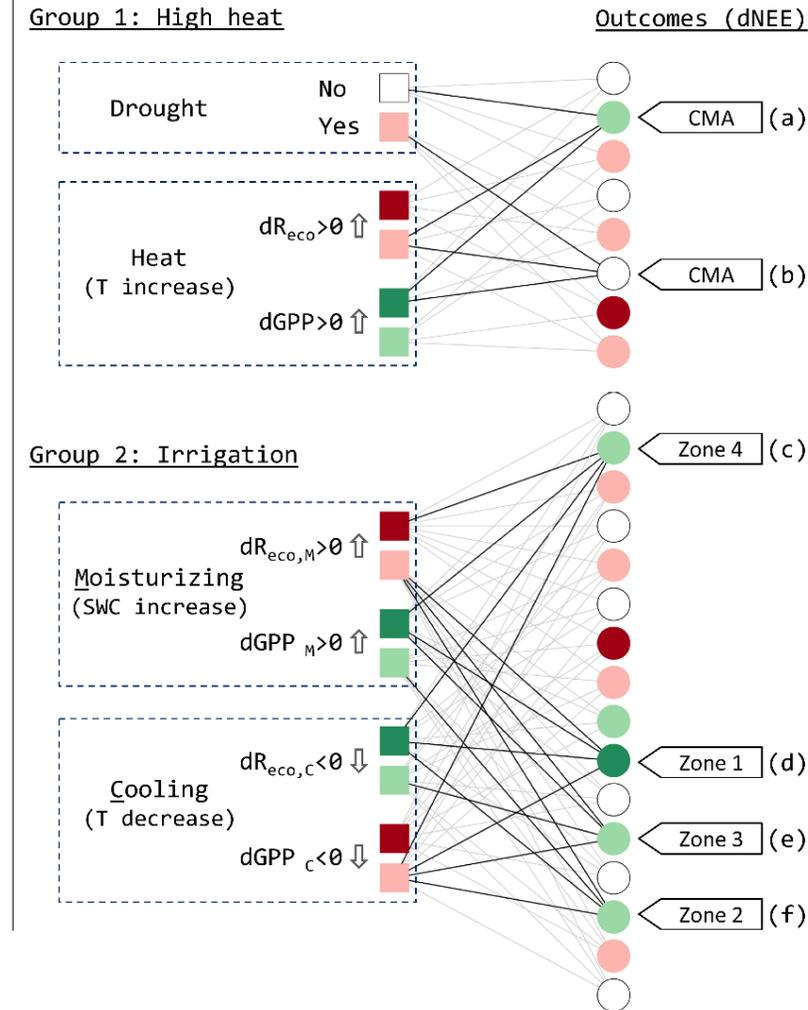
Net ecosystem exchange (NEE)



- Best, EBS +2
- Good, EBS +1
- Neutral, EBS 0
- Bad, EBS -1
- Worst, EBS -2



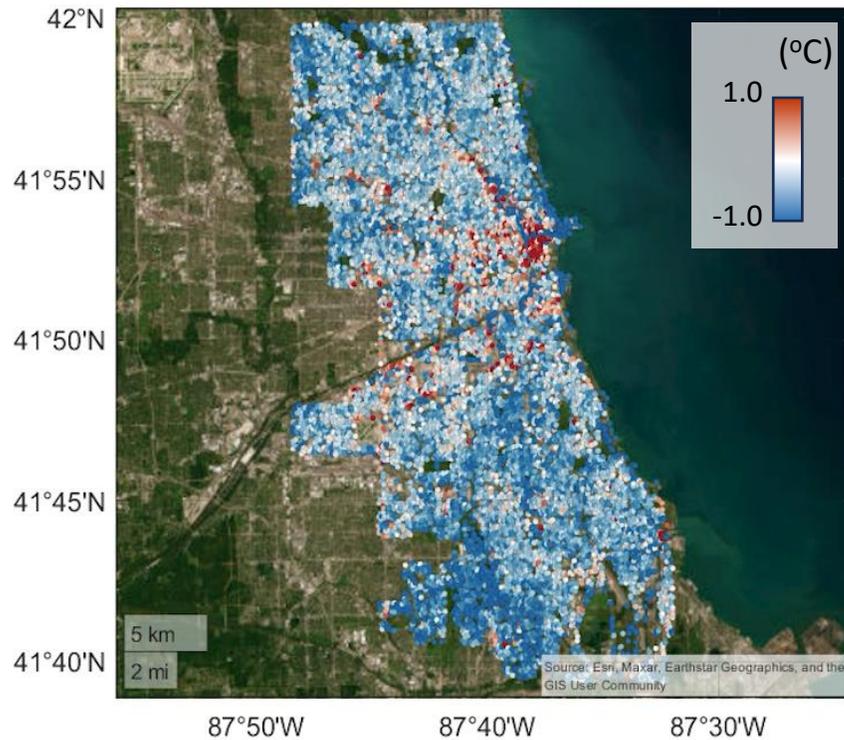
Environmental benefit score



Solutions at scales it matters

- A physical-informed machine learning framework to estimate street-level environmental stressors

Temperature deviation from areal mean (hourly)



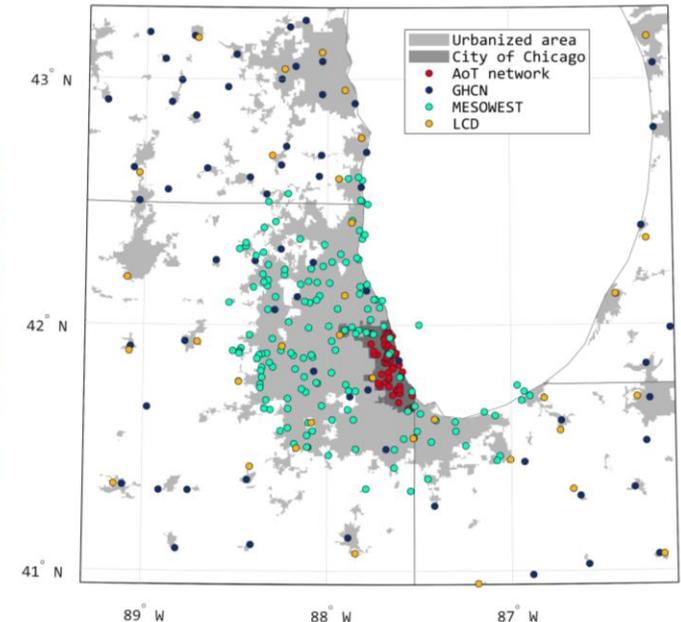
Li and Sharma (in review; JAMES)

LiDAR point cloud dataset (ILHMP, 2018)

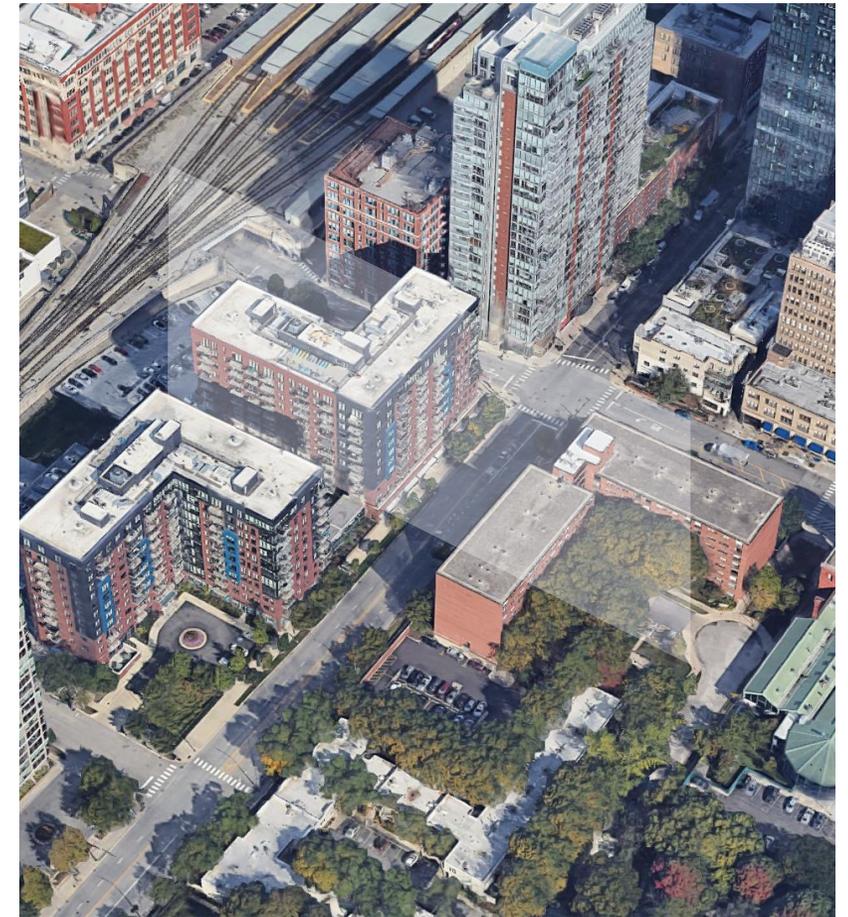
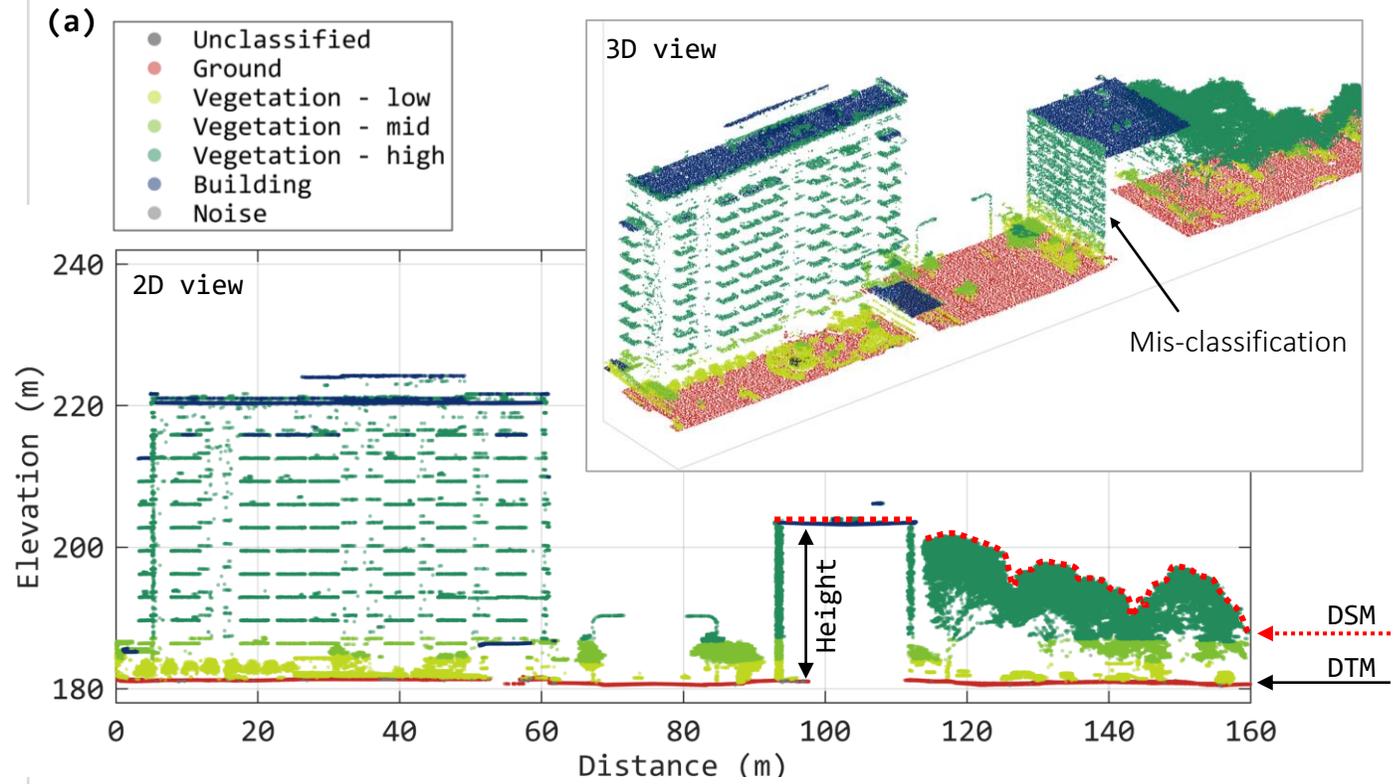


Li and Sharma (in review; ERL)

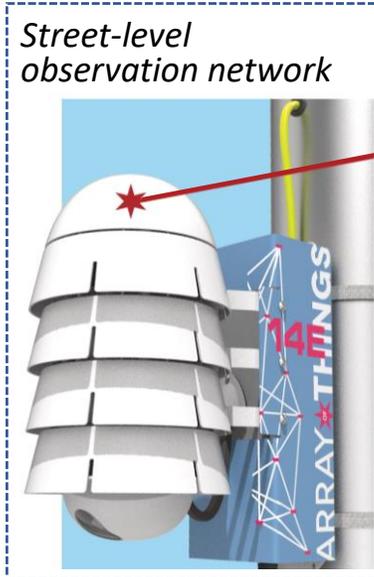
Weather stations and nodes around Chicago area



- LiDAR data at an exemplary street block

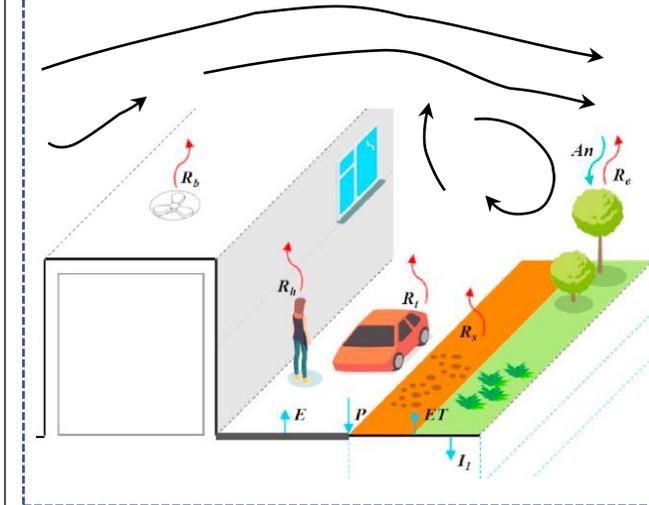


Urban informatics



Urban Weather Forecast

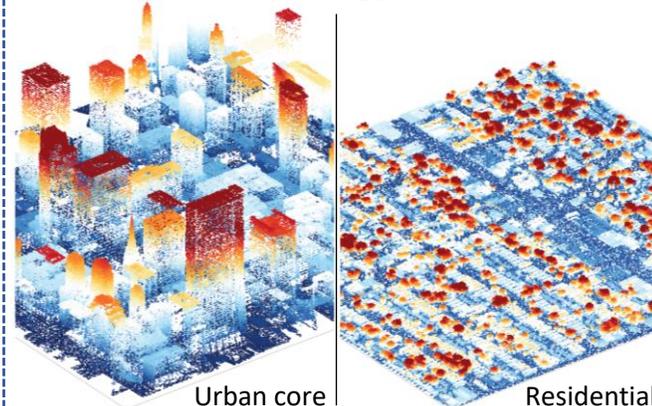
WRF/urban modeling framework



Parcel-level land use inventory

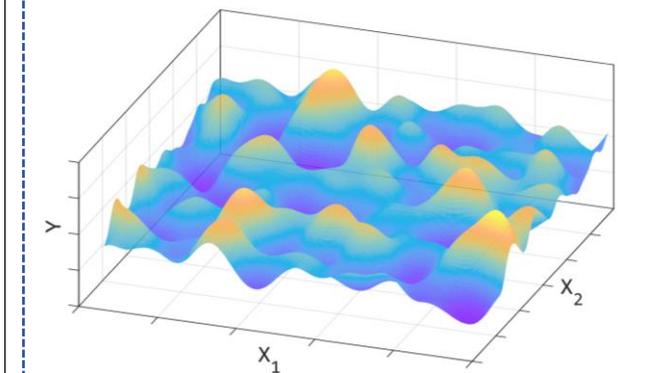


LiDAR urban morphology



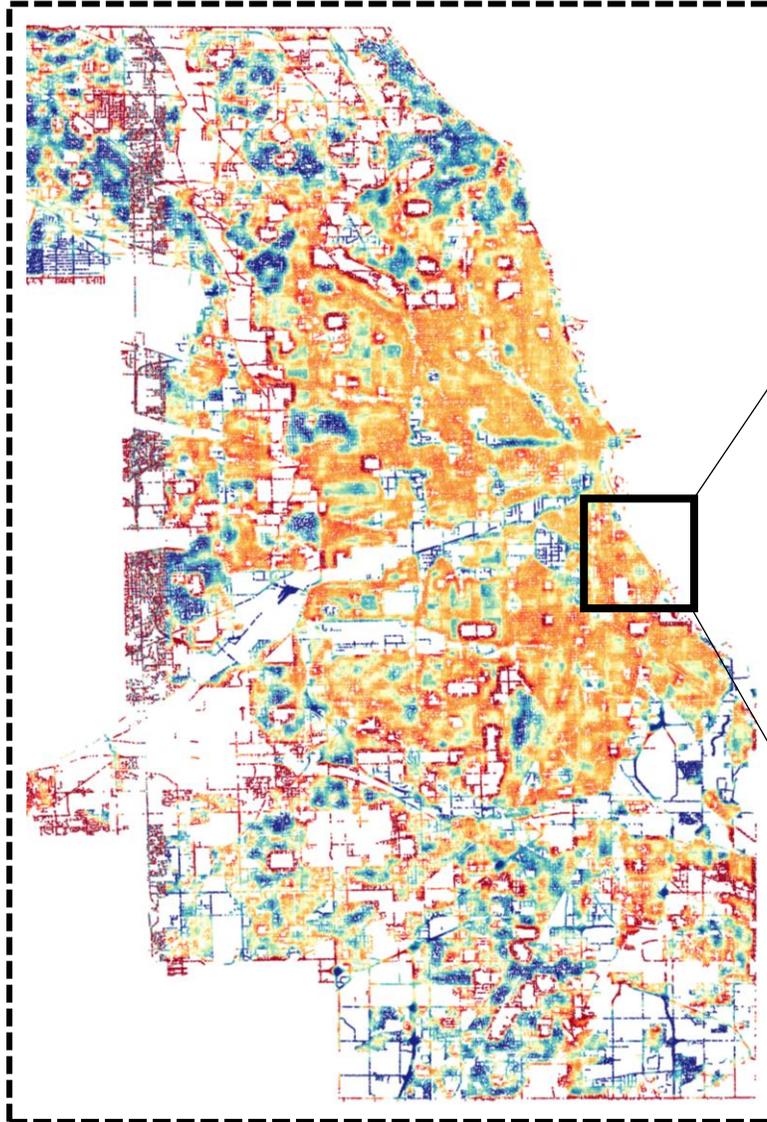
Machine Learning

Gaussian Process Regression



- Forecasting street-level temperature via data fusion of urban informatics

Street-level temperature estimation



Street-level air temperature at resampled locations

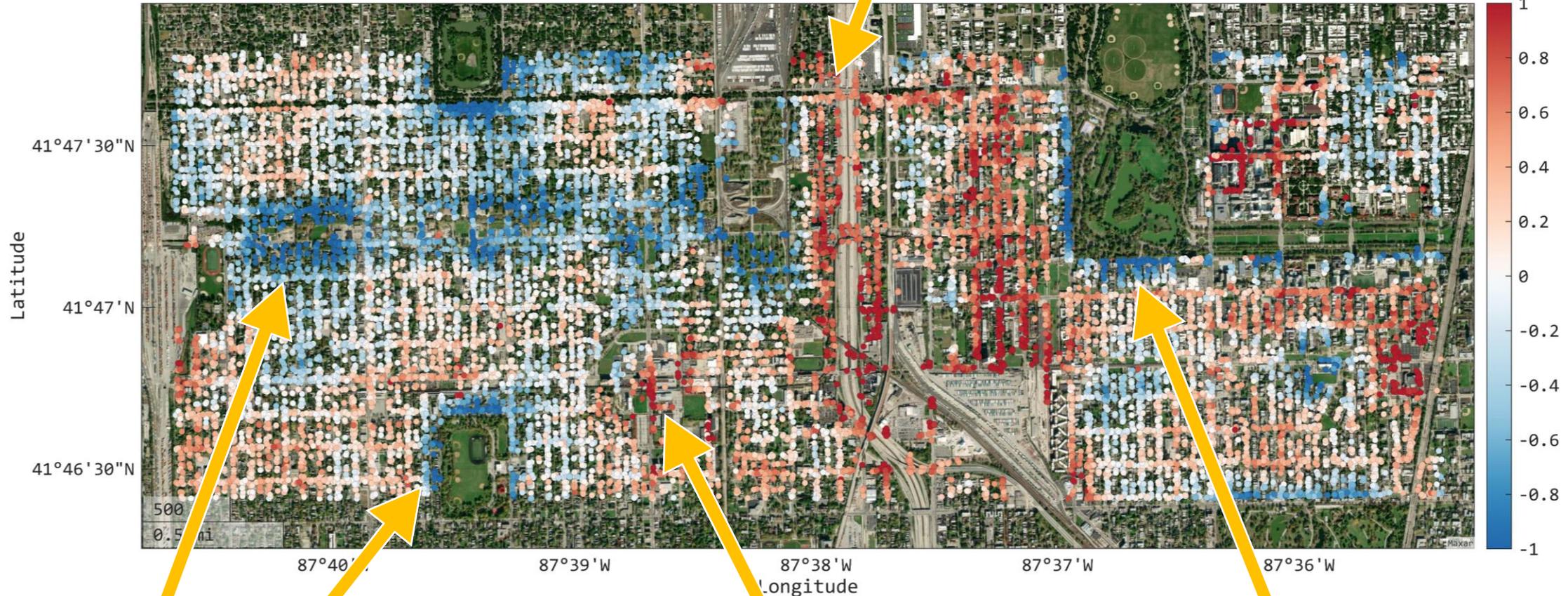


- Downscale 1-km climate prediction to sub-meter street-level air temperature using machine learning.

Address Urban Planning issues at street scales

Temperature deviation from spatial mean

Area along the freeways, no shading, is hotter



Area with dense vegetation is cooler.

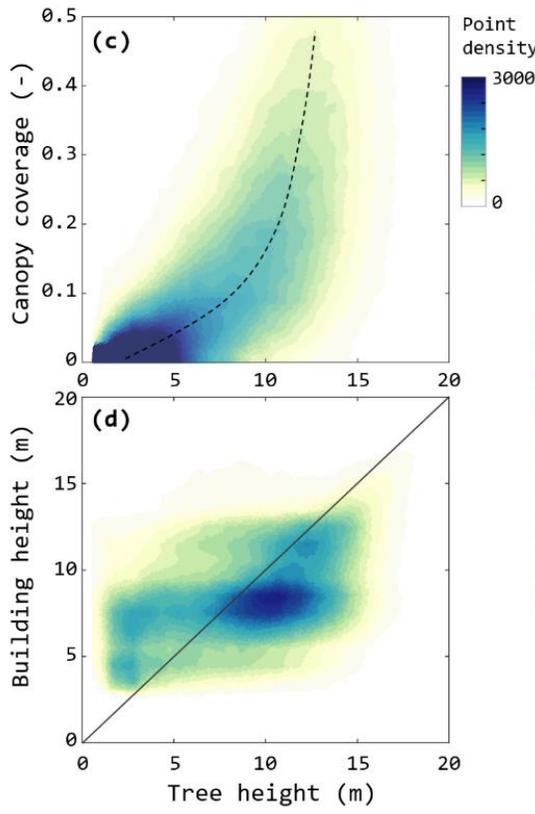
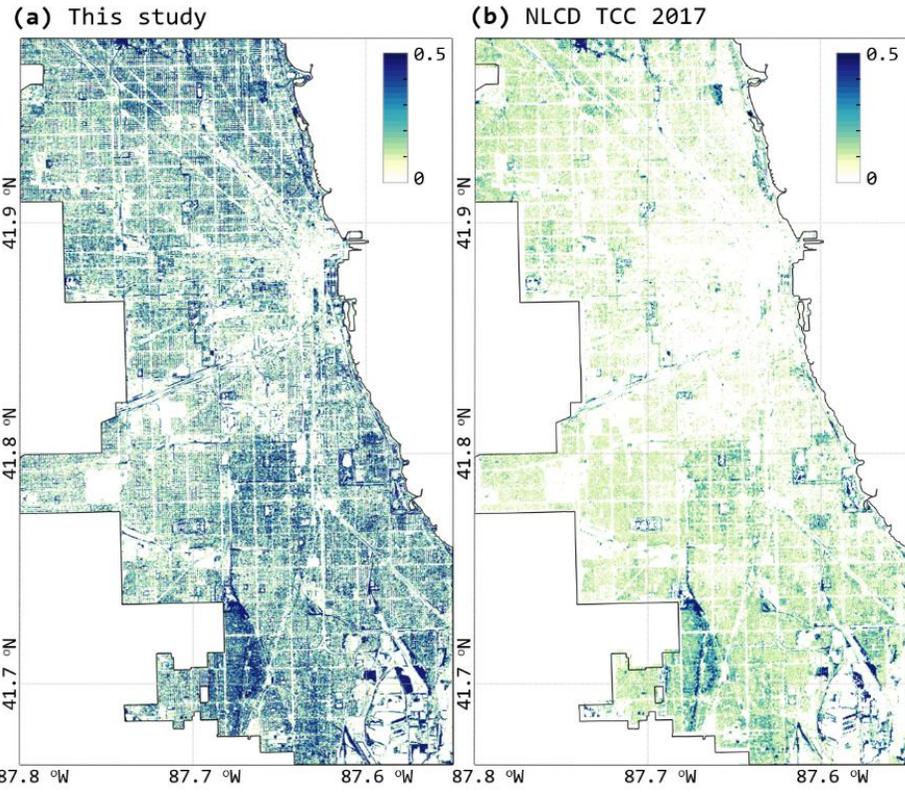
Commercial corners are hotter

Li and Sharma (in review)

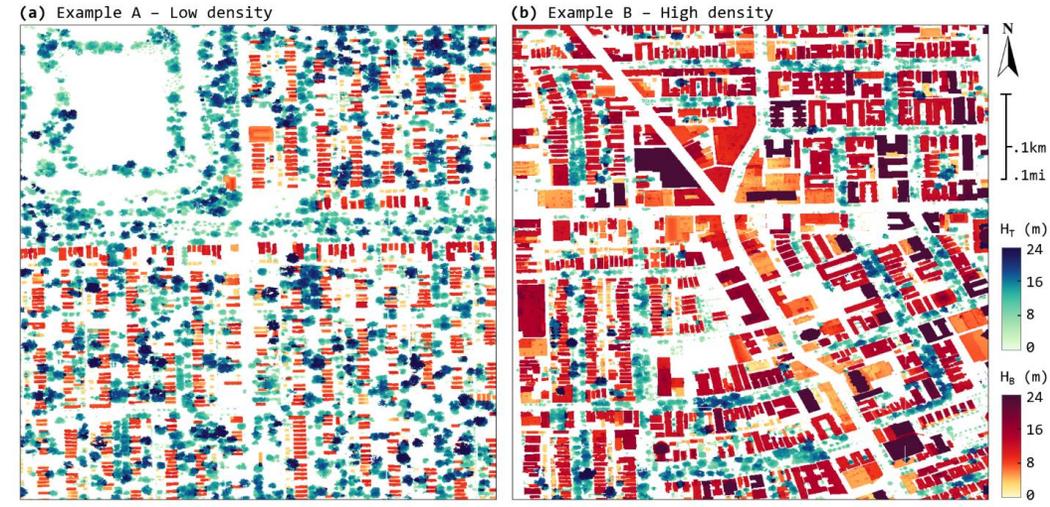
Street near large urban parks is cooler

HiTAB-Chicago: Height map of Trees And Buildings for the City of Chicago

Tree canopy coverage



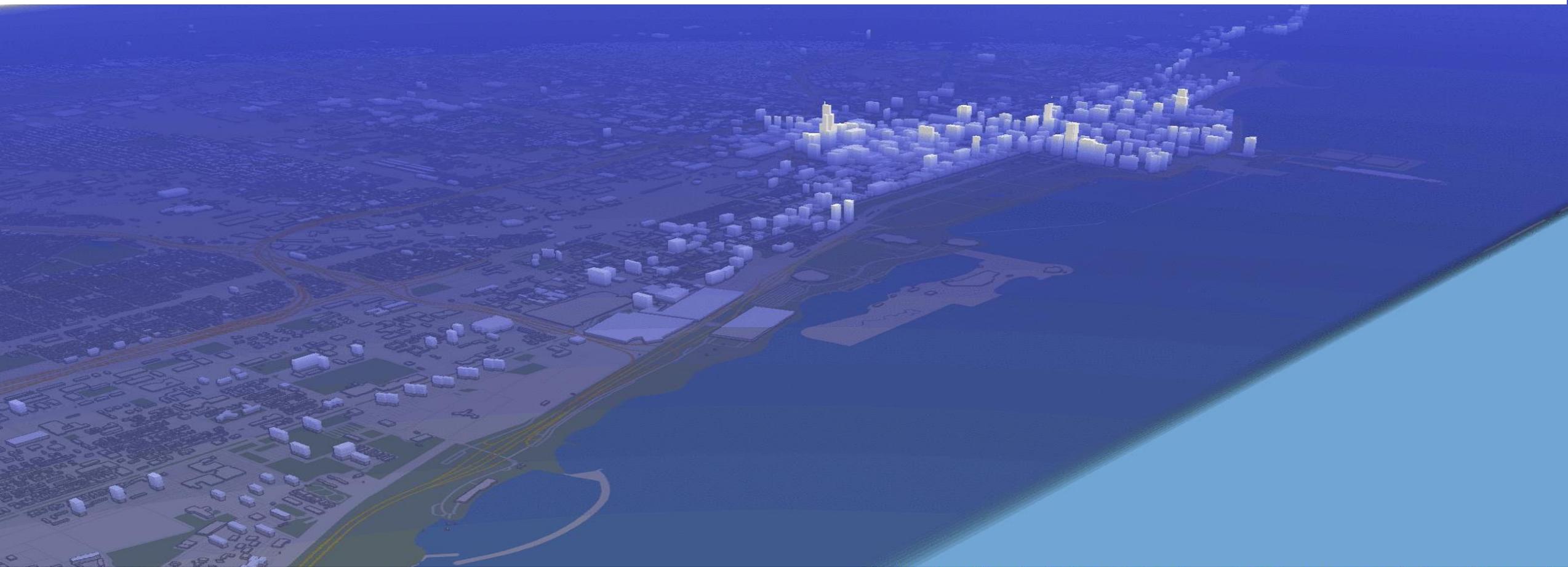
Building height



Open source data available at:
<https://doi.org/10.5281/zenodo.10463648>

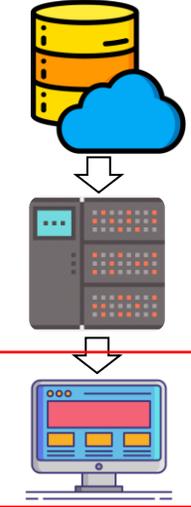
Urban products/tools

3D visualization



Applications

- Shadow impact of two buildings on Millennium Park (3-5 pm)

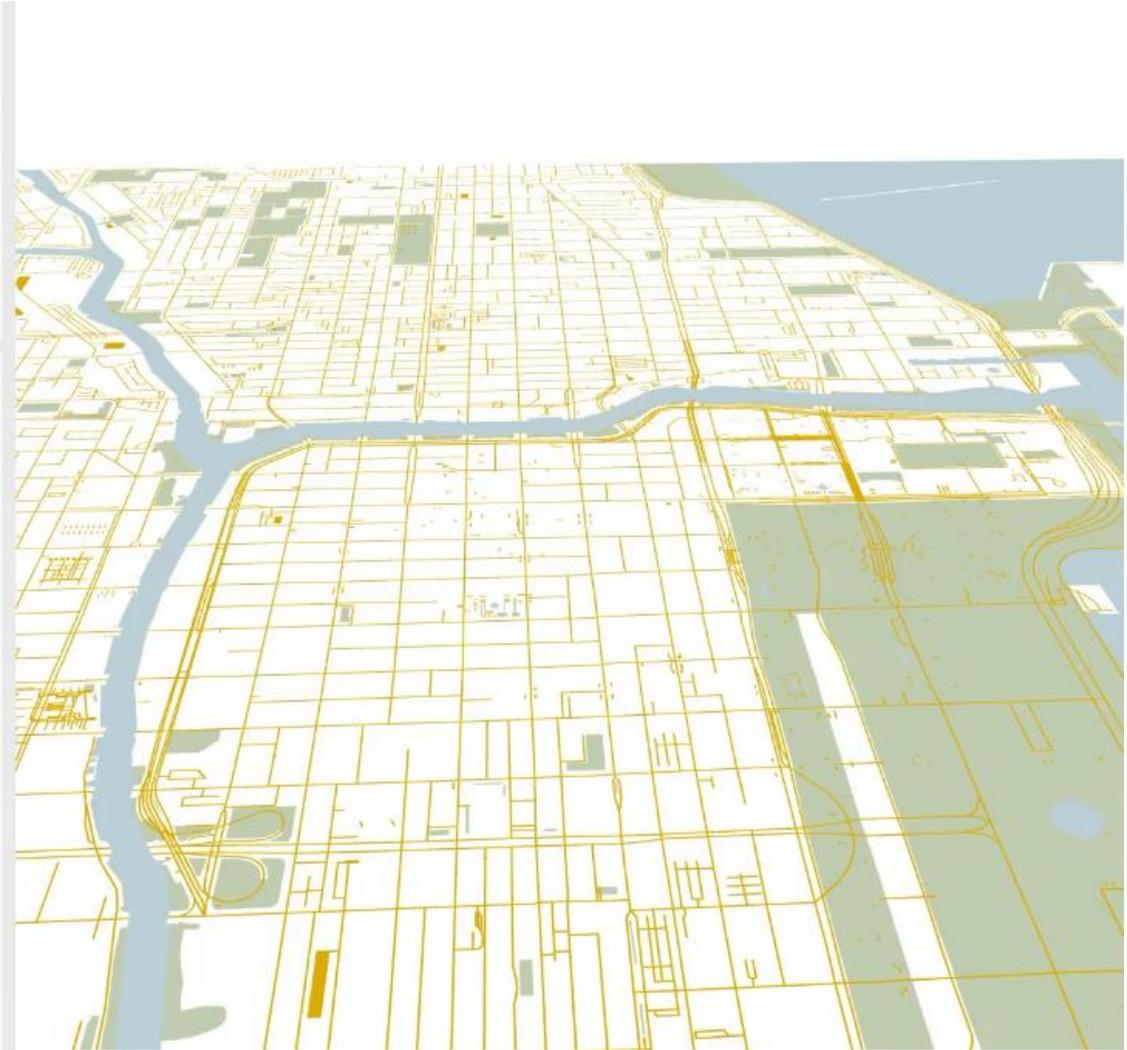


Layers

- pureParks
- pureRoads
- pureWater

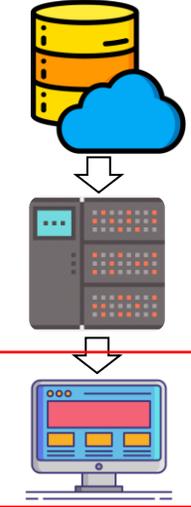
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26  ],
27  },
28  },
29  "knots": [
30    "pureParks",
31    "pureWater",
32    "pureRoads"
33  ],
34  "interactions": [
35    "NONE",
36    "NONE",
37    "NONE"
38  ],
39  },
40  "plots": [],
41  "knots": [
42    {
43      "id": "pureParks",
44      "integration_scheme": {
45        "out": {
46
```

Apply Grammar Link



Applications

- Shadow impact of two buildings on Millennium Park (3-5 pm)

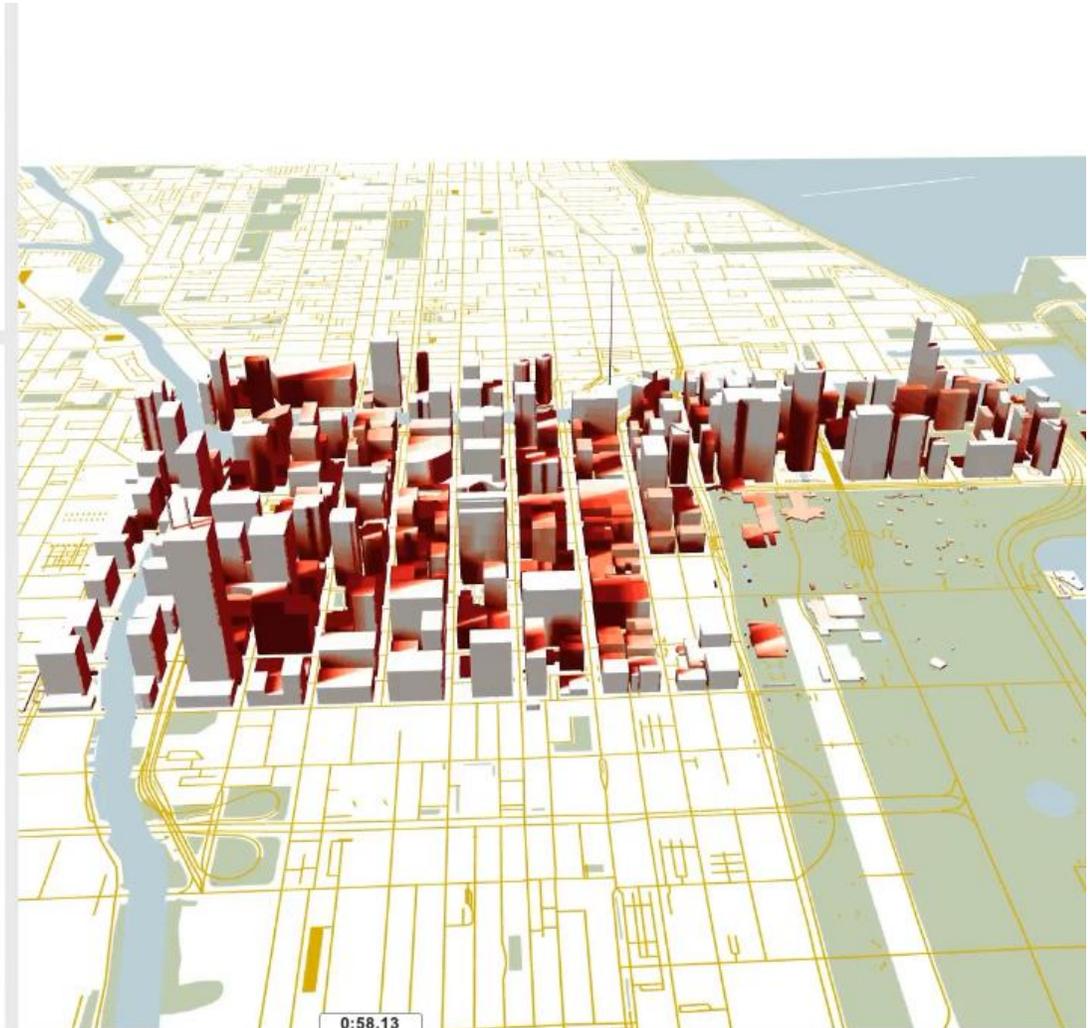


Layers

- pureWater
- shadowToSurfaceM
- shadowToSurface
- whatIfSurface
- shadowBuildingsM

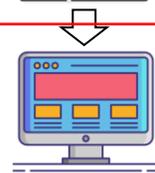
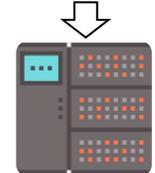
```
1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9754472,
8             5115001,
9             2.076573974609375
10          ],
11         "direction": {
12           "right": [
13             -360.5781555175781,
14             -3128.7470703125,
15             2076.573974609375
16           ],
17           "lookAt": [
18             -280.4845275878906,
19             -598.5999755859375,
20             466.6234436035156
21           ],
22           "up": [
23             0.016979672014713287,
24             0.5363814830780029,
25             0.8438048362731934
26           ]
27         }
28       }
29     }
30   ]
31 }
```

Apply Grammar Link



Applications

- Shadow impact of two buildings on Millennium Park (3-5 pm)



Layers

- pureWater
- shadowToSurfaceM
- shadowToSurface
- whatIfSurface
- shadowBuildingsM

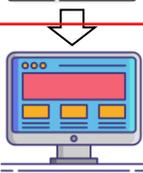
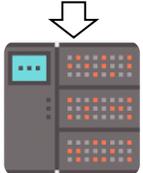
```
1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9754472,
8             5115001,
9             2.076573974609375
10          ],
11         "direction": {
12           "right": [
13             -360.5781555175781,
14             -3128.7470703125,
15             2076.573974609375
16           ],
17           "lookAt": [
18             -280.4845275878906,
19             -598.5999755859375,
20             466.6234436035156
21           ],
22           "up": [
23             0.016979672014713287,
24             0.5363814830780029,
25             0.8438048362731934
26           ]
27         }
28       }
29     }
30   ]
31 }
```

Apply Grammar Link



Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



Layers

- water
- parks
- buildings
- wrf

```
1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9753739,
8             5117375.5,
9             76.332125
10          ],
11          "direction": {
12            "right": [
13              -5756.0478515625,
14              -4202.9482421875,
15              76332.125
16            ],
17            "lookAt": [
18              -5756.0478515625,
19              -4202.9482421875,
20              73332.125
21            ],
22            "up": [
23              0,
24              1,
25              0
26            ]
27          }
28        }
29      }
30    ]
31  }
```

Apply Grammar Link

Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



Layers

- water
- parks
- buildings
- wrf

0 1 2 3 4 5 6 7 8 9 10 11 12

0 1 2 3 4 5 6 7 8 9 10 11 12

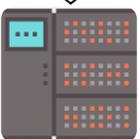
```
1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9753739,
8             5117375.5,
9             76.332125
10          ],
11         "direction": {
12           "right": [
13             -5756.0478515625,
14             -4202.9482421875,
15             76332.125
16           ],
17           "lookAt": [
18             -5756.0478515625,
19             -4202.9482421875,
20             73332.125
21           ],
22           "up": [
23             0,
24             1,
25             0
26           ]
27         }
28       }
29     }
30   ]
31 }
```

Apply Grammar Link



Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data

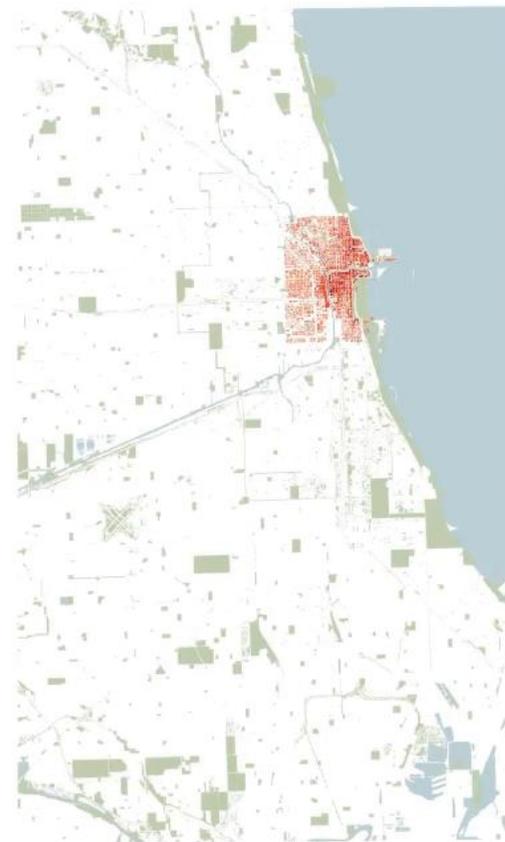


Layers

- water
- parks
- buildings
- wrf

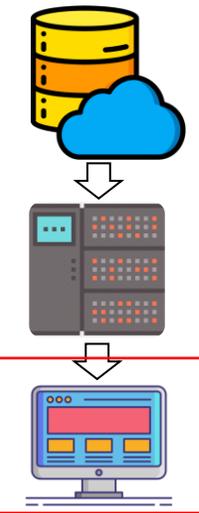
```
1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9753739,
8             5117375.5,
9             76.332125
10          ],
11          "direction": {
12            "right": [
13              -5756.0478515625,
14              -4202.9482421875,
15              76332.125
16            ],
17            "lookAt": [
18              -5756.0478515625,
19              -4202.9482421875,
20              73332.125
21            ],
22            "up": [
23              0,
24              1,
25              0
26            ]
27          }
28        }
29      }
30    ]
31  }
```

Apply Grammar Link



Applications

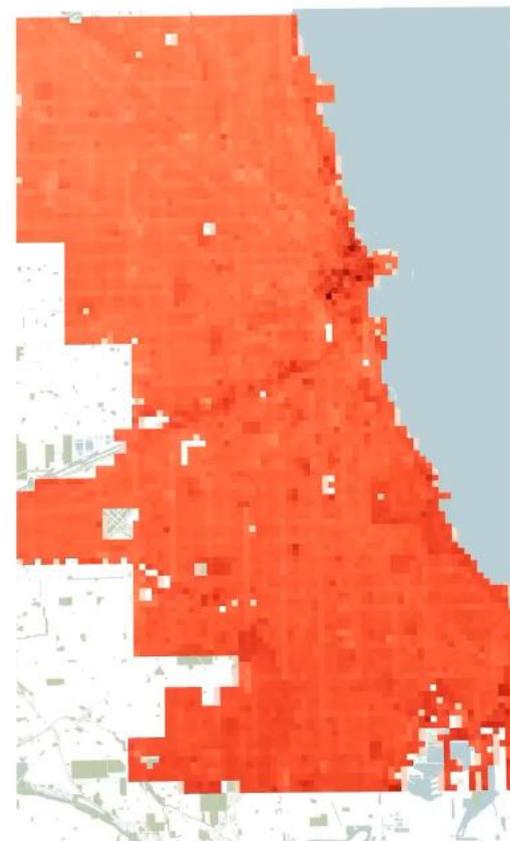
- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



Layers

- water
- parks
- buildings 1 2 3 4 5 6 7 8 9 10 11 12
- wrf 1 2 3 4 5 6 7 8 9 10 11 12

```
1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9753739,
8             5117375.5,
9             76.332125
10          ],
11          "direction": {
12            "right": [
13              -5756.0478515625,
14              -4202.9482421875,
15              76332.125
16            ],
17            "lookAt": [
18              -5756.0478515625,
19              -4202.9482421875,
20              73332.125
21            ],
22            "up": [
23              0,
24              1,
25              0
26            ]
27          }
28        }
29      }
30    ]
31  }
```



Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data

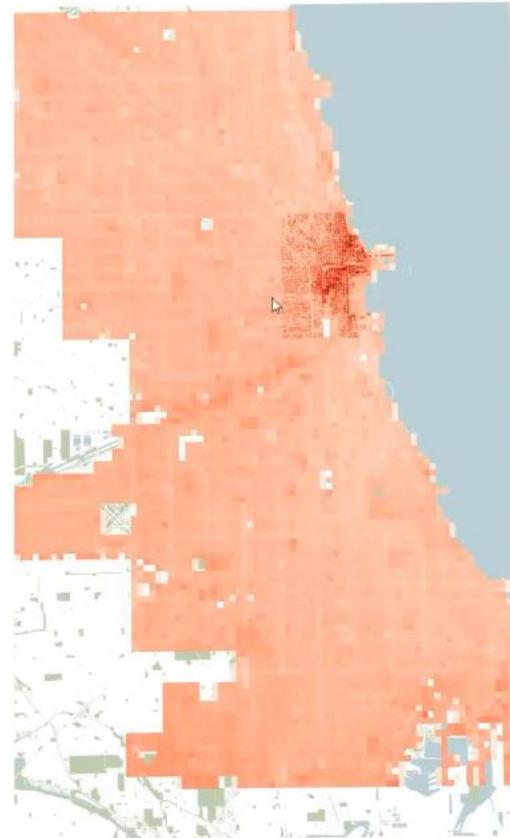


Layers

- water
- parks
- buildings 1 2 3 4 5 6 7 8 9 10 11 12
- wrf 1 2 3 4 5 6 7 8 9 10 11 12

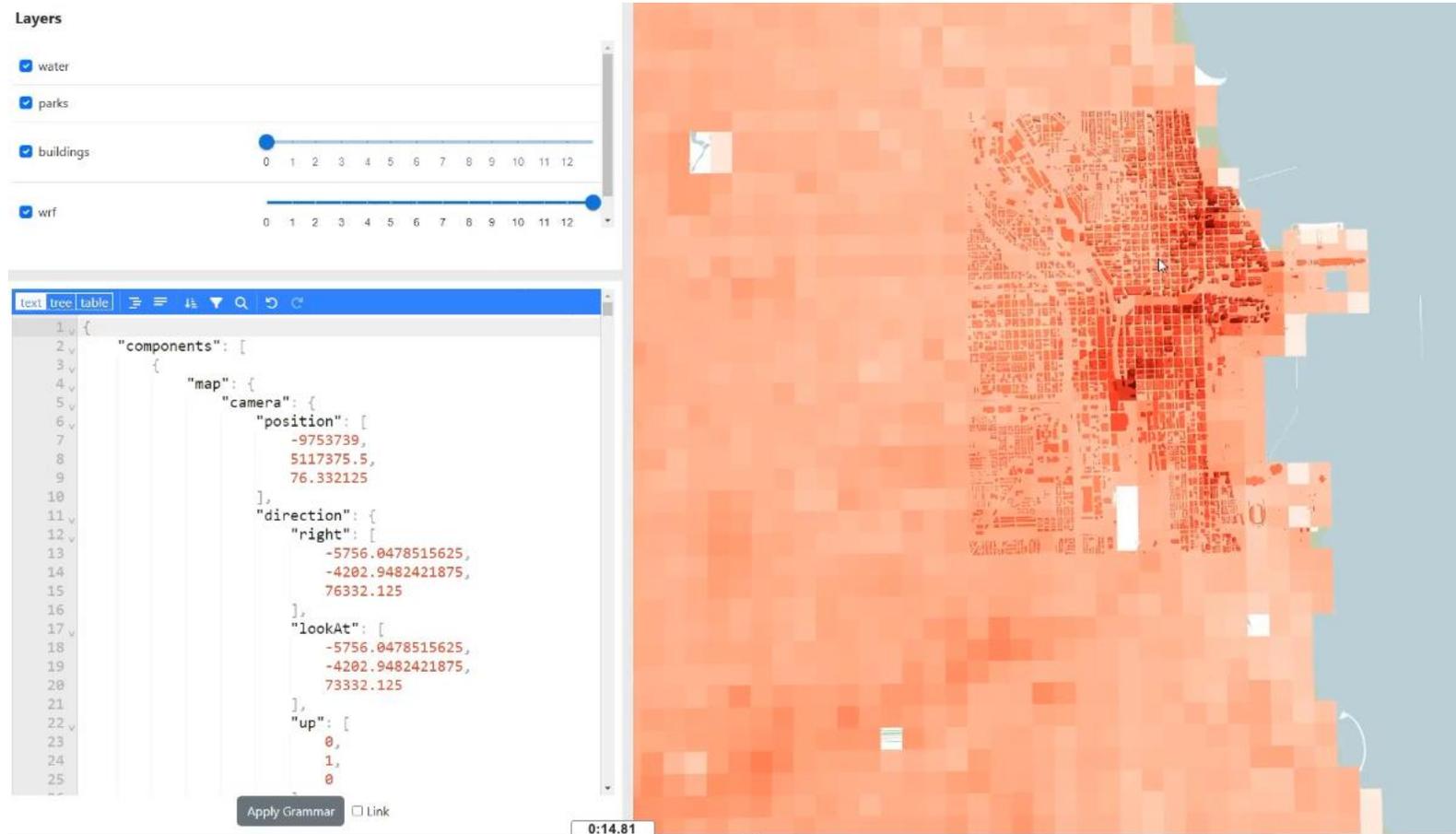
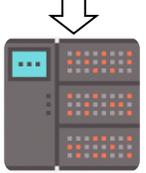
```
1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9753739,
8             5117375.5,
9             76.332125
10          ],
11          "direction": {
12            "right": [
13              -5756.0478515625,
14              -4202.9482421875,
15              76332.125
16            ],
17            "lookAt": [
18              -5756.0478515625,
19              -4202.9482421875,
20              73332.125
21            ],
22            "up": [
23              0,
24              1,
25              0
26            ]
27          }
28        }
29      }
30    ]
31  }
```

Apply Grammar Link



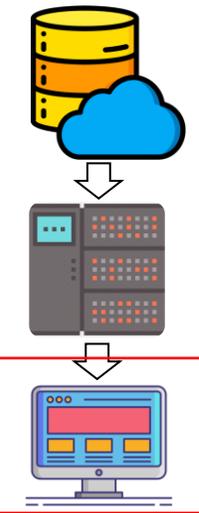
Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



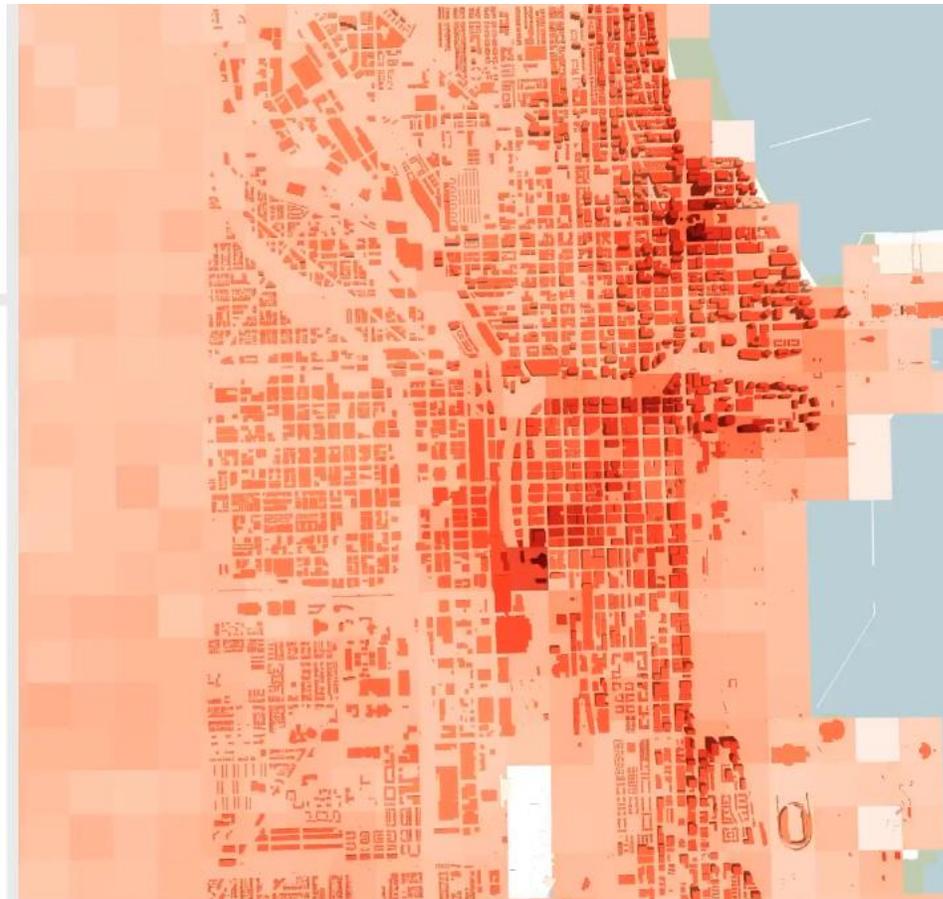
Layers

- water
- parks
- buildings
- wrf

```

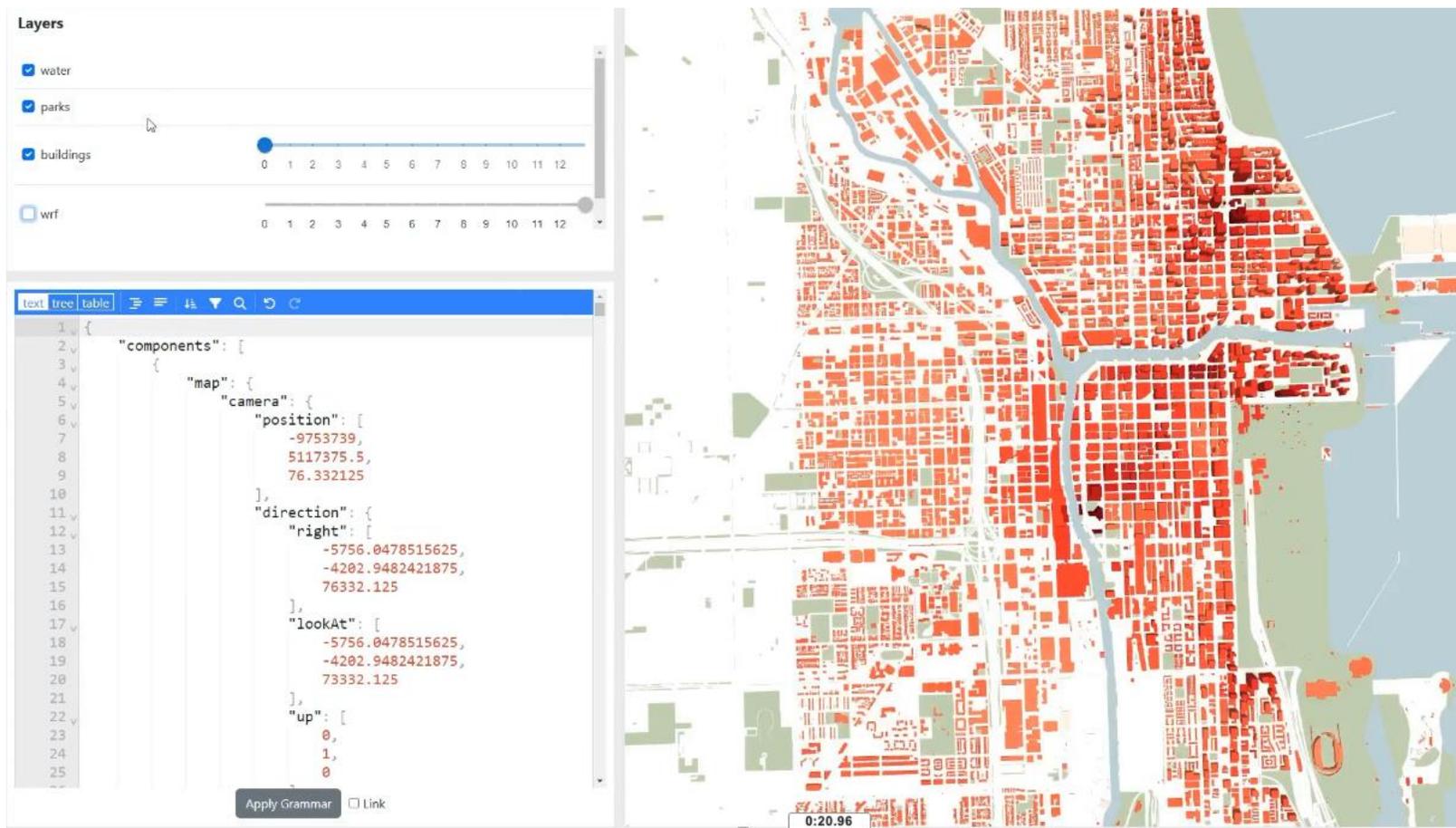
1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9753739,
8             5117375.5,
9             76.332125
10          ],
11         "direction": {
12           "right": [
13             -5756.0478515625,
14             -4202.9482421875,
15             76332.125
16           ],
17           "lookAt": [
18             -5756.0478515625,
19             -4202.9482421875,
20             73332.125
21           ],
22           "up": [
23             0,
24             1,
25             0
  
```

Apply Grammar Link



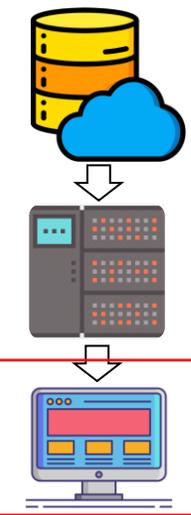
Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



Layers

- water
- parks
- buildings 0 1 2 3 4 5 6 7 8 9 10 11 12
- wrf 0 1 2 3 4 5 6 7 8 9 10 11 12

text tree table

```

1 {
2   "components": [
3     {
4       "map": {
5         "camera": {
6           "position": [
7             -9753739,
8             5117375.5,
9             76.332125
10          ],
11          "direction": {
12            "right": [
13              -5756.0478515625,
14              -4202.9482421875,
15              76332.125
16            ],
17            "lookAt": [
18              -5756.0478515625,
19              -4202.9482421875,
20              73332.125
21            ],
22            "up": [
23              0,
24              1,
25              0

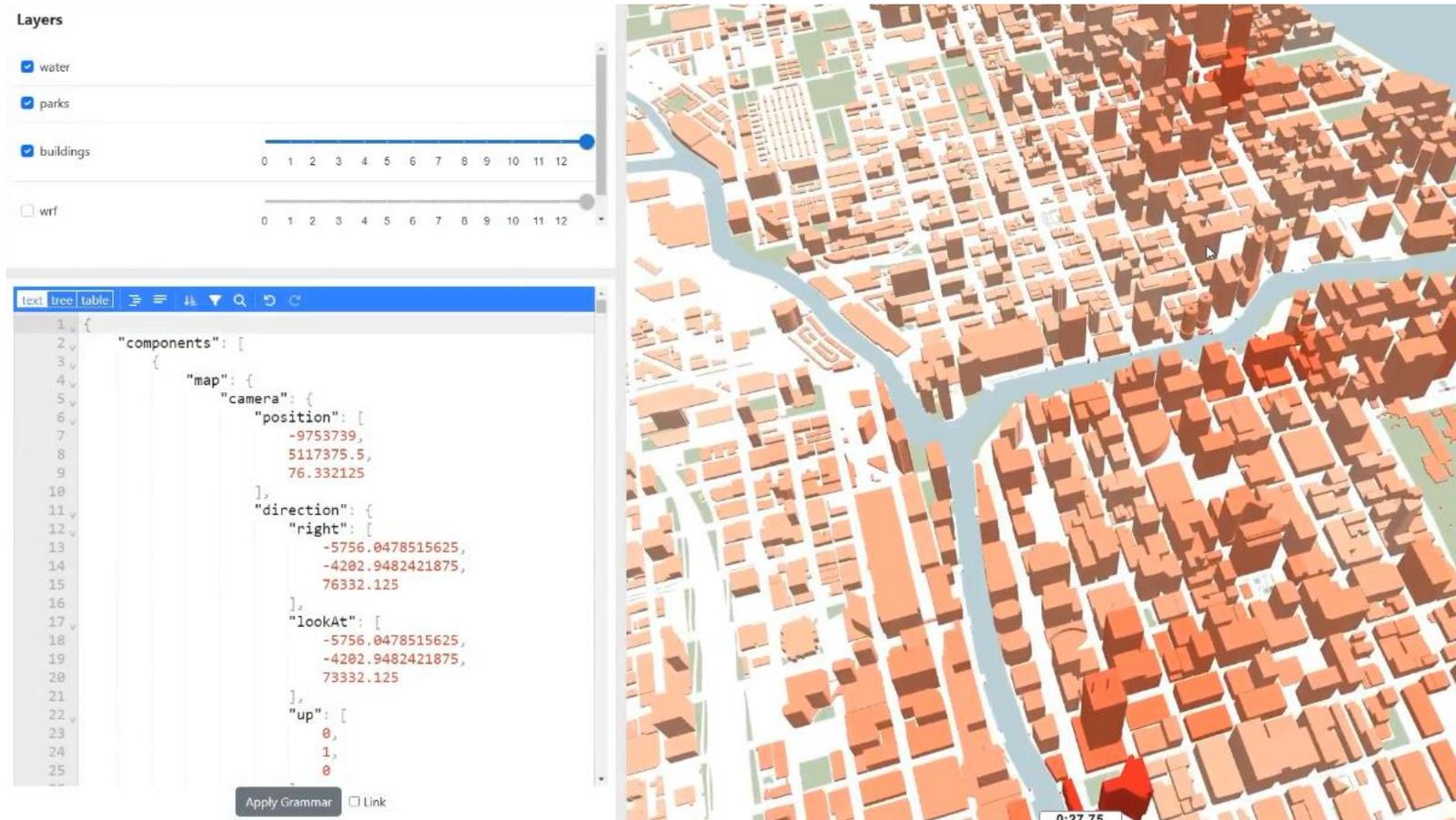
```

Apply Grammar Link



Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



The screenshot displays a 3D city model interface. On the left, a 'Layers' panel is visible with the following settings:

- water
- parks
- buildings (with a slider set to 12)
- wrf (with a slider set to 12)

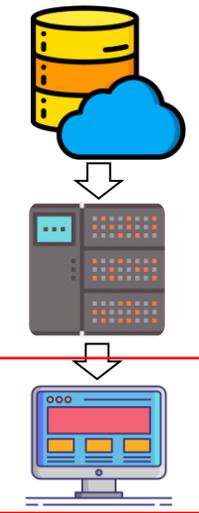
Below the layers panel, a code editor shows the following JSON configuration:

```
1 {  
2   "components": [  
3     {  
4       "map": {  
5         "camera": {  
6           "position": [  
7             -9753739,  
8             5117375.5,  
9             76.332125  
10          ],  
11         "direction": {  
12           "right": [  
13             -5756.0478515625,  
14             -4202.9482421875,  
15             76332.125  
16           ],  
17           "lookAt": [  
18             -5756.0478515625,  
19             -4202.9482421875,  
20             73332.125  
21           ],  
22           "up": [  
23             0,  
24             1,  
25             0  
26           ]  
27         }  
28       }  
29     ]  
30   }  
31 }
```

The 3D model on the right shows a city with orange buildings, a blue river, and a red camera icon. The interface includes a toolbar with options like 'text', 'tree', and 'table', and a status bar at the bottom showing '0:27.75'.

Applications

- WRF temperature data at the street and building levels.
- Combining 1 km and 250 m resolution climate simulation data



Layers

water

parks

buildings 0 1 2 3 4 5 6 7 8 9 10 11 12

wrf 0 1 2 3 4 5 6 7 8 9 10 11 12

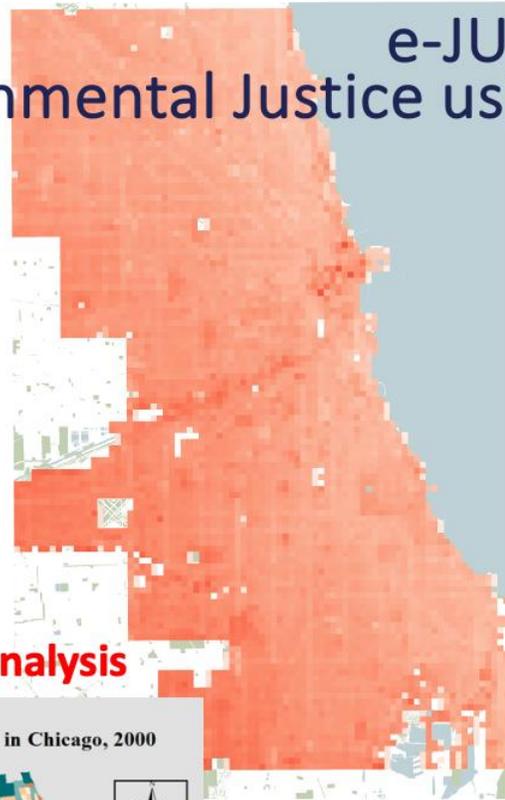
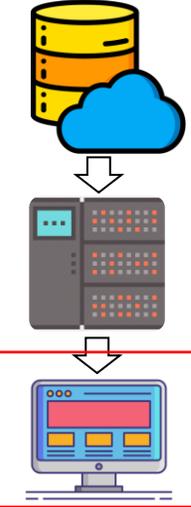
```

1  {
2  "components": [
3  {
4    "map": {
5      "camera": {
6        "position": [
7          -9753739,
8          5117375.5,
9          76.332125
10       ],
11      "direction": {
12        "right": [
13          -5756.0478515625,
14          -4202.9482421875,
15          76332.125
16        ],
17        "lookAt": [
18          -5756.0478515625,
19          -4202.9482421875,
20          73332.125
21        ],
22        "up": [
23          0,
24          1,
25          0

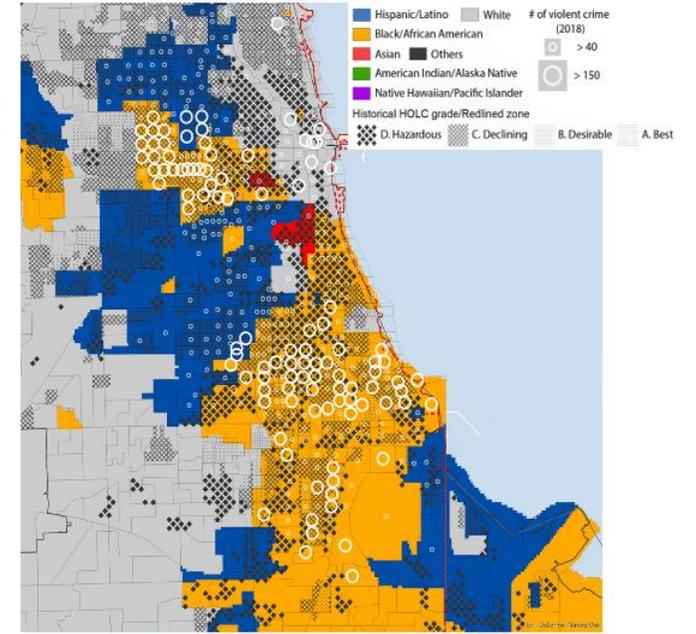
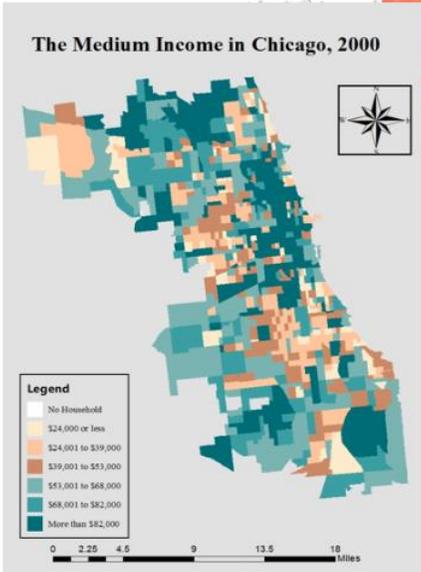
```

0:29.52

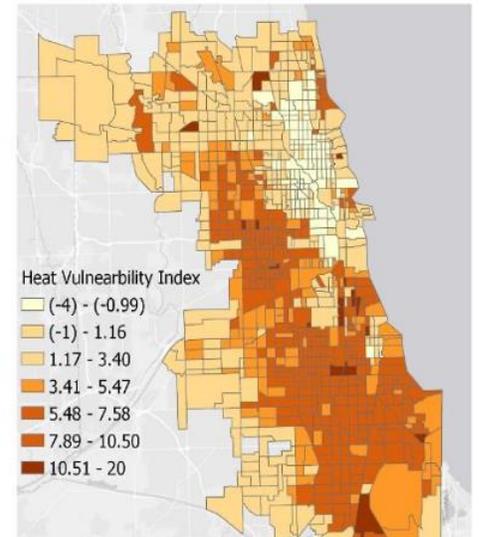
e-JUST — Environmental Justice using Urban Scalable Toolkit



Income analysis



Heat Vulnerability Index



Sharma et al. (2018) *Env. Res. Lett.*

Observed Data



Urban Climate Models

WRF
WRF-Chem

Demographic Dataset

2020 US Census

e-JUST

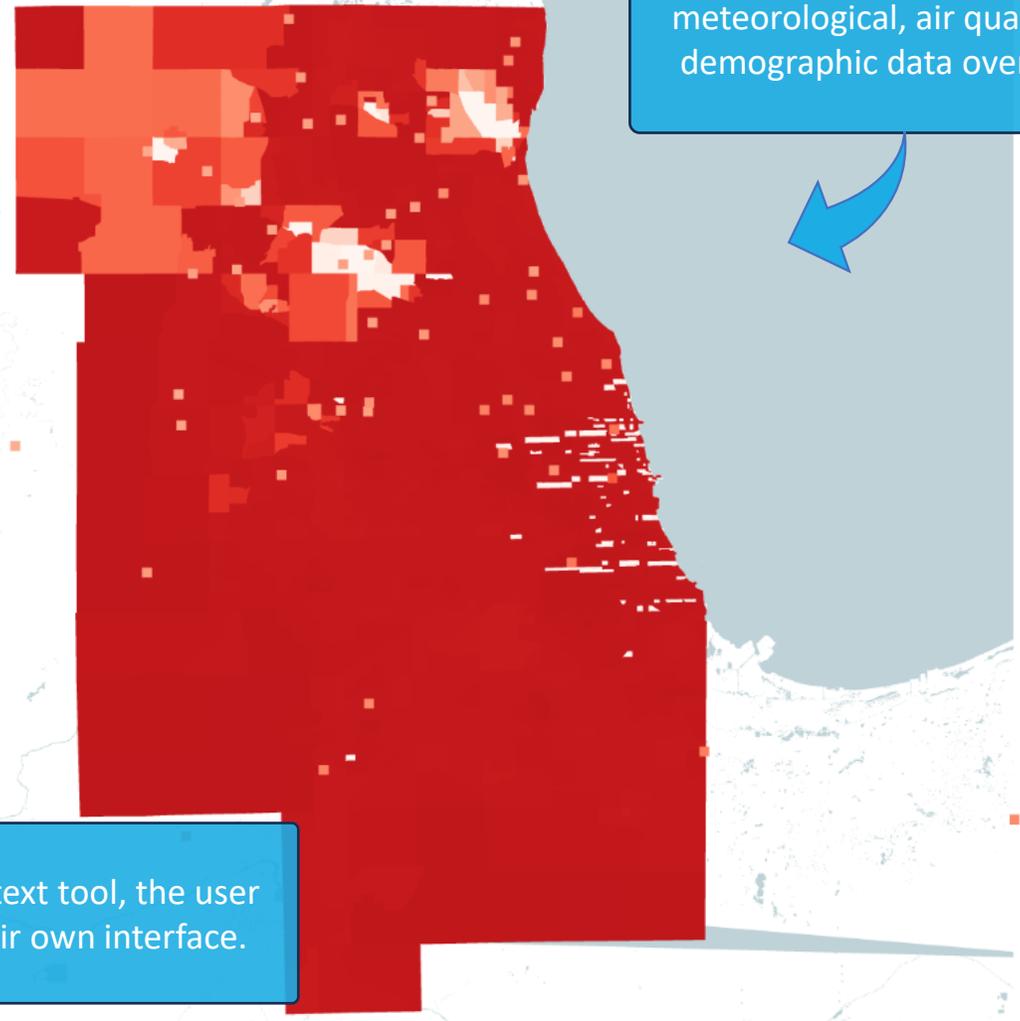


Decision-Making

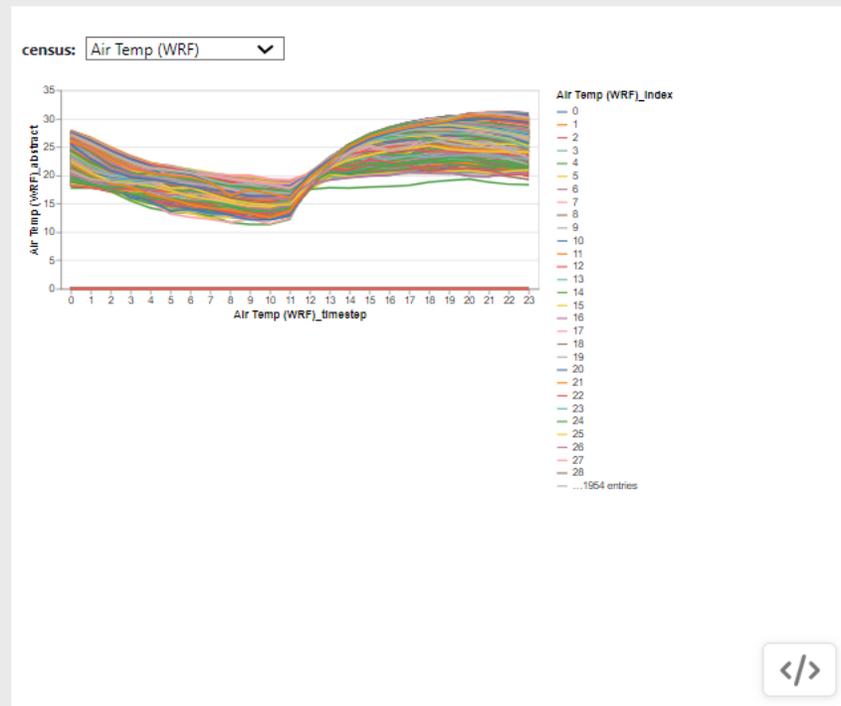
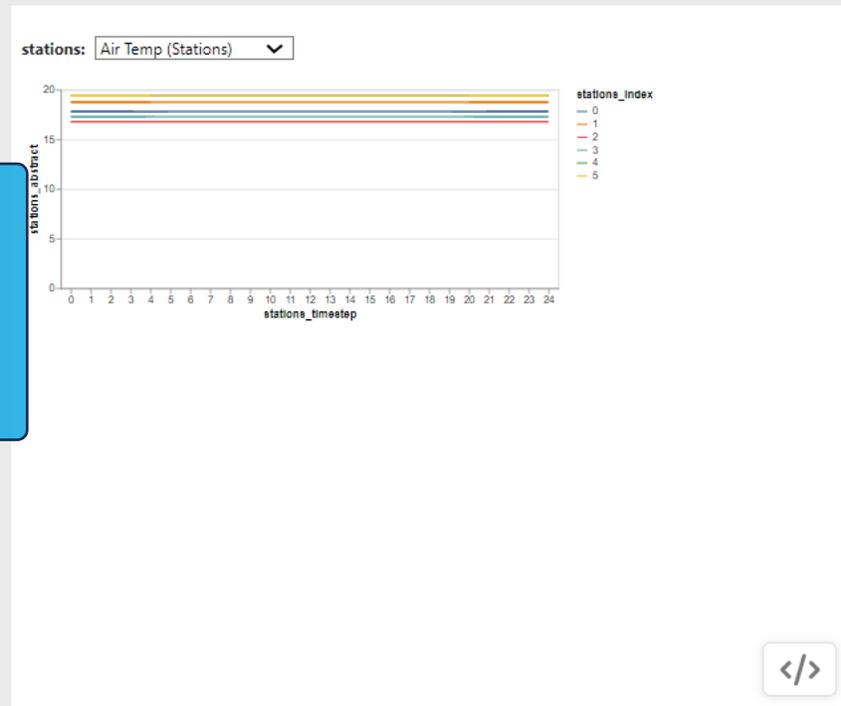
```
1- components: [
2-   {
3-     "id": "grammar_map",
4-     "position": {
5-       "width": [
6-         3,
7-         8
8-       ],
9-       "height": [
10-        1,
11-        4
12-      ]
13-    }
14-  },
15-  {
16-    "id": "grammar_plot",
17-    "position": {
18-      "width": [
19-        9,
20-        12
21-      ],
22-      "height": [
23-        1,
24-        2
25-      ]
26-    }
27-  },
28-  {
29-    "id": "grammar_plot2",
30-    "position": {
31-      "width": [
32-        9,
33-        12
34-      ],
35-      "height": [
36-        3,
37-        4
38-      ]
39-    }
40-  },
41- ],
42- "knots": [
43-   {
44-     "id": "Lake",
45-     "integration_scheme": [
46-       {
47-         "out": {
48-           "name": "water",
49-           "level": "OBJECTS"
50-         }
51-       }
52-     ]
53-   },
54-   {
55-     "id": "Air Temp (WRF)",
56-     "range": [
57-       0,
58-       1
59-     ],
60-     "domain": [
61-       0,
62-       50
63-     ],
64-     "integration_scheme": [
65-       {
66-         "spatial_relation": CONTAINS
67-       }
68-     ],
69-     "in": {
70-       "name": "tair2016",
71-       "level": "COORDINATES"
72-     }
73-   }
74- ]
```

Lake
 Air Temp (WRF) 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22
 Air Temp (MODIS) 0 1
 Air Temp (Stations) 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

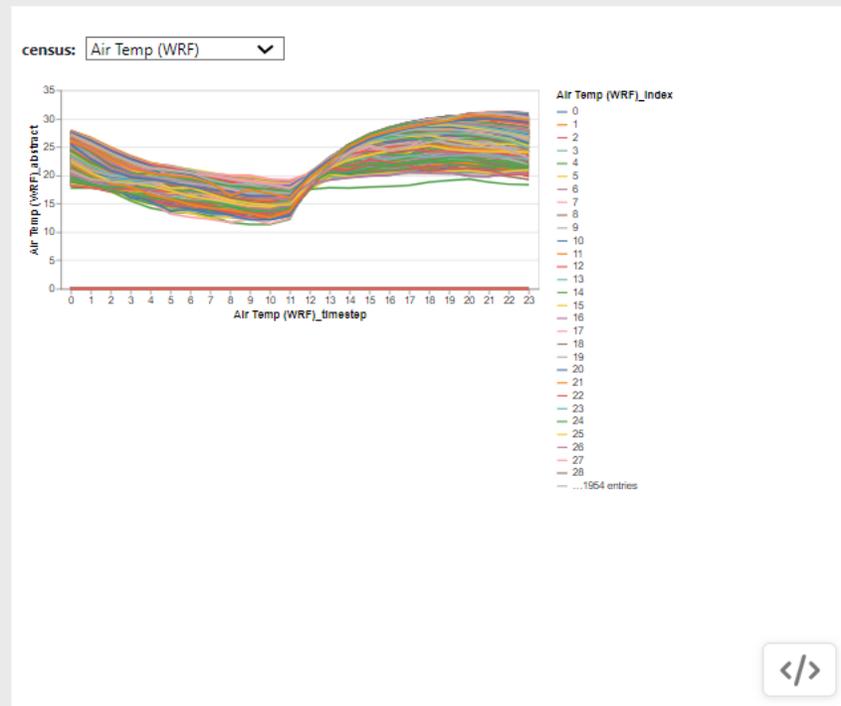
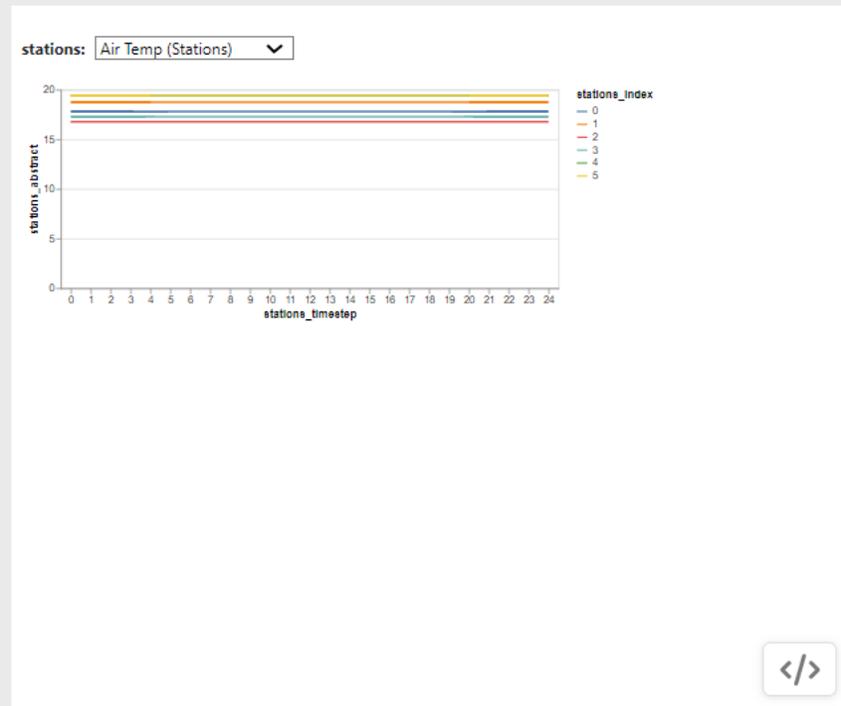
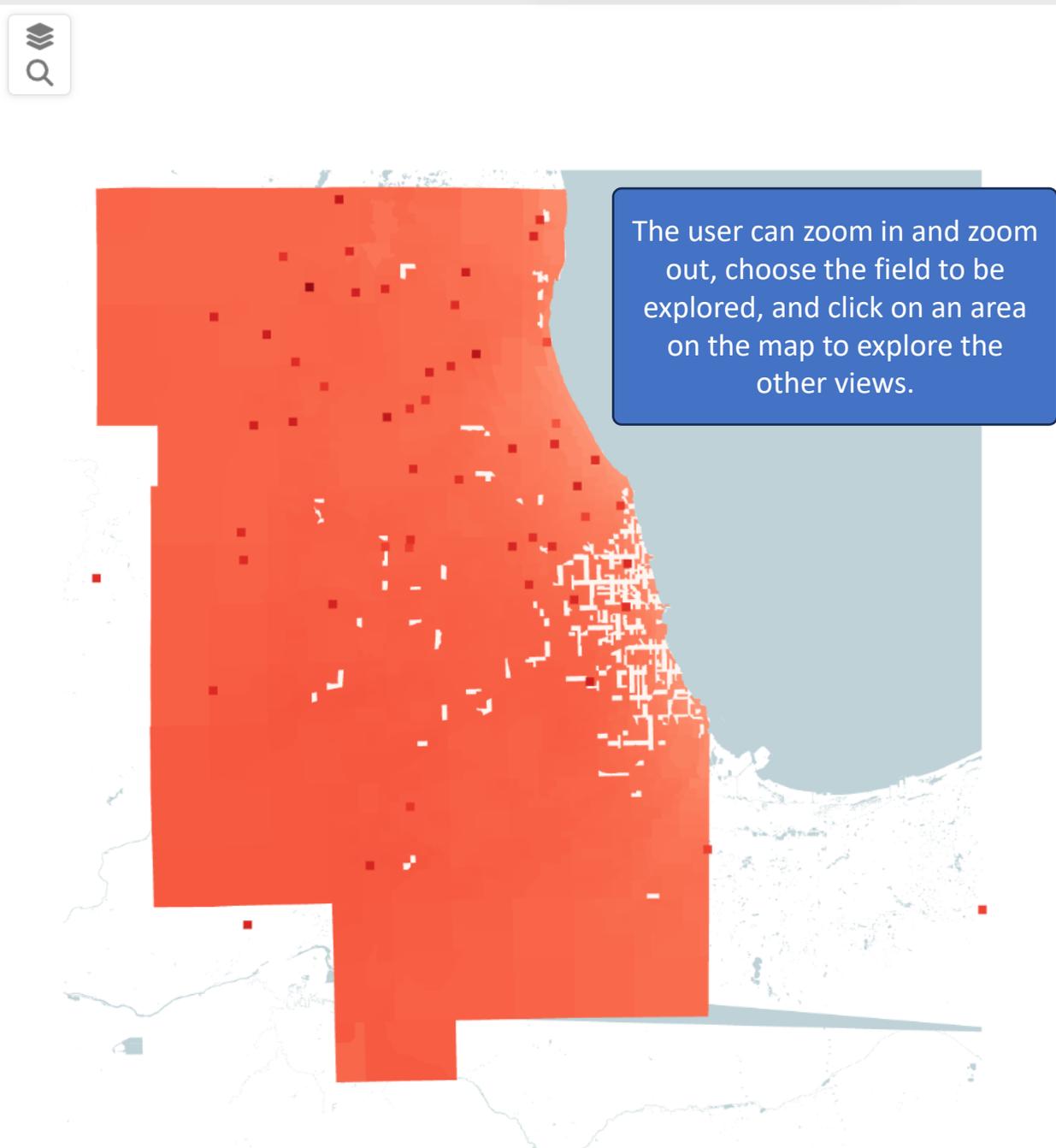
Spatial View:
Interactive map to explore meteorological, air quality and demographic data over space



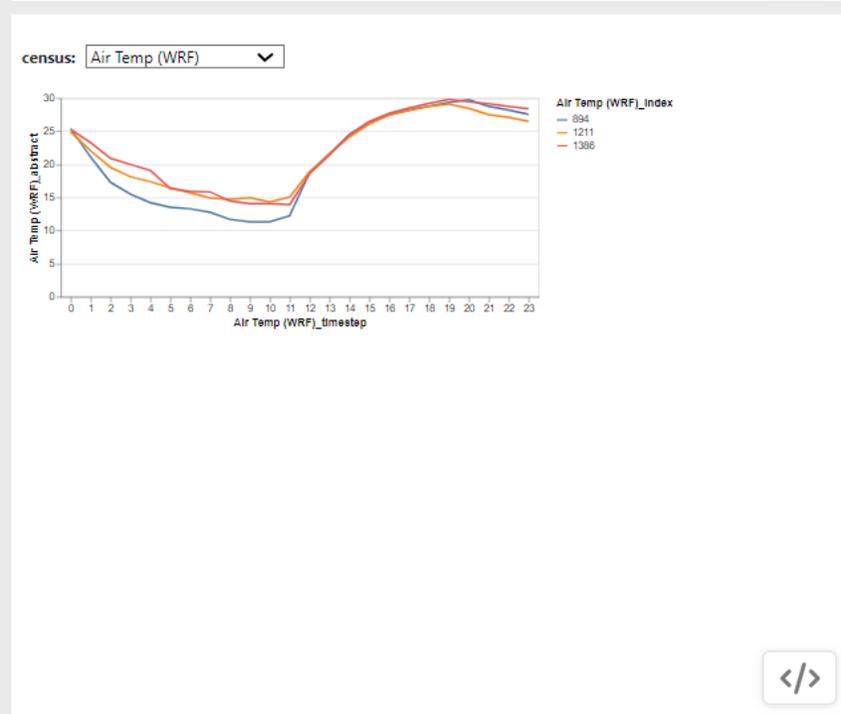
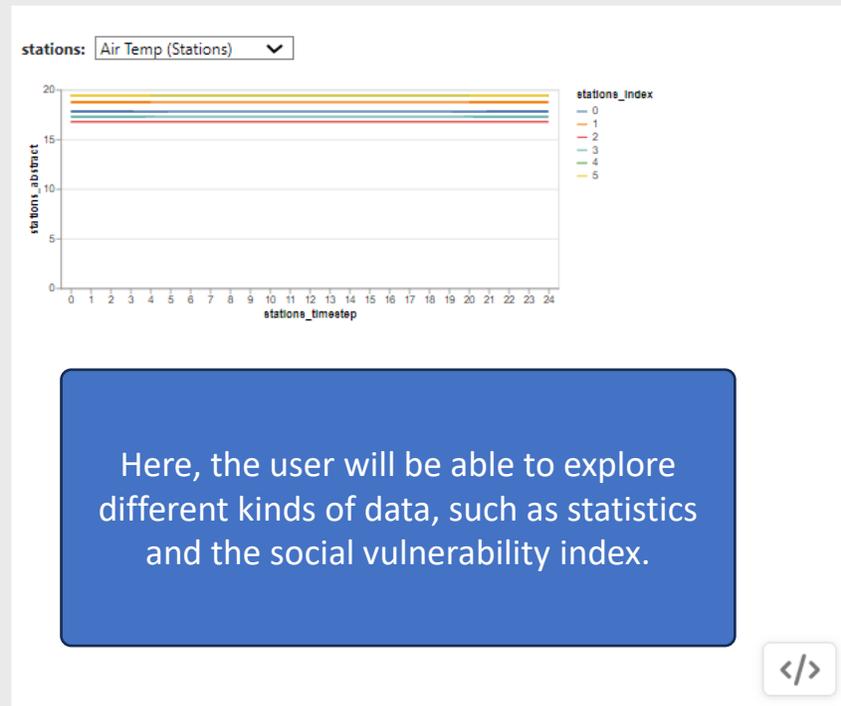
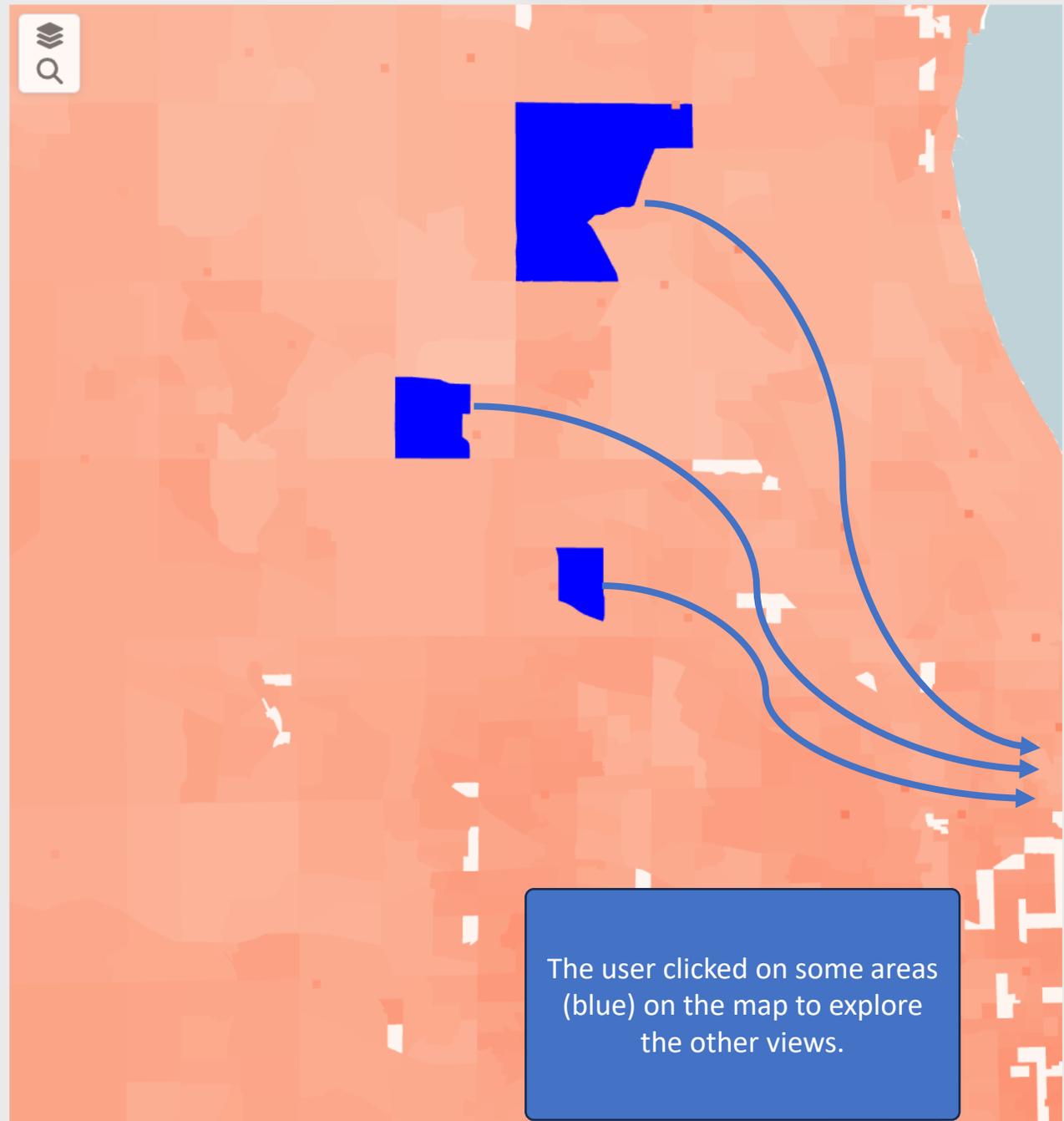
Through this text tool, the user can build their own interface.



```
1- |
2- | "components": [
3- |   {
4- |     "id": "grammar_map",
5- |     "position": {
6- |       "width": [
7- |         3,
8- |         8
9- |       ],
10- |     "height": [
11- |       1,
12- |       4
13- |     ]
14- |   },
15- |   {
16- |     "id": "grammar_plot",
17- |     "position": {
18- |       "width": [
19- |         9,
20- |         12
21- |       ],
22- |     "height": [
23- |       1,
24- |       2
25- |     ]
26- |   },
27- |   {
28- |     "id": "grammar_plot2",
29- |     "position": {
30- |       "width": [
31- |         9,
32- |         12
33- |       ],
34- |     "height": [
35- |       3,
36- |       4
37- |     ]
38- |   }
39- | ],
40- | "knots": [
41- |   {
42- |     "id": "Lake",
43- |     "integration_scheme": [
44- |       {
45- |         "out": {
46- |           "name": "water",
47- |           "level": "OBJECTS"
48- |         }
49- |       }
50- |     ]
51- |   },
52- |   {
53- |     "id": "Air Temp (WRF)",
54- |     "range": [
55- |       0,
56- |       1
57- |     ],
58- |     "domain": [
59- |       0,
60- |       50
61- |     ],
62- |     "integration_scheme": [
63- |       {
64- |         "spatial_relation": "CONTAINS"
65- |       },
66- |       {
67- |         "in": {
68- |           "name": "tair2016_24h",
69- |           "level": "COORDINATES"
70- |         }
71- |       }
72- |     ]
73- |   }
74- | ]
```



```
1- components: [
2- {
3-   "id": "grammar_map",
4-   "position": {
5-     "width": [
6-       3,
7-       8
8-     ],
9-     "height": [
10-      1,
11-      4
12-    ]
13-  },
14- },
15- {
16-   "id": "grammar_plot",
17-   "position": {
18-     "width": [
19-       9,
20-       12
21-     ],
22-     "height": [
23-       1,
24-       2
25-     ]
26-   },
27- },
28- {
29-   "id": "grammar_plot2",
30-   "position": {
31-     "width": [
32-       9,
33-       12
34-     ],
35-     "height": [
36-       3,
37-       4
38-     ]
39-   },
40- },
41- ],
42- knots: [
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49-         "level": "OBJECTS"
50-       }
51-     }
52-   ],
53- },
54- ],
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67-       "spatial_relation": "CONTAINS"
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71-         "name": "tair2016_24h",
72-         "level": "COORDINATES"
73-       }
74-     }
75-   ]
76- }
77- ]
```



Example of interactivity (1)

The screenshot displays a web-based interactive application. On the left is a code editor showing JSON data for components, knots, and integration schemes. The central map shows a coastal area with orange terrain and blue water, with several blue rectangular overlays. A control panel in the top center includes checkboxes for 'Lake', 'Air Temp (WRF)', 'Air Temp (MODIS)', and 'Air Temp (Stations)', along with sliders for the WRF and Stations data. On the right, two line graphs are shown. The top graph is titled 'stations: Air Temp (Stations)' and plots 'stations_abstract' (y-axis, 0-20) against 'stations_timestep' (x-axis, 0-24). The bottom graph is titled 'census: Air Temp (WRF)' and plots 'Air Temp (WRF)_abstract' (y-axis, 0-30) against 'Air Temp (WRF)_timestep' (x-axis, 0-24). Both graphs show multiple lines representing different data series. The interface includes 'Apply Grammar' and 'Link' buttons at the bottom left, and code editor icons at the bottom right.

Example of interactivity (2)

The screenshot displays a web application interface for data visualization. On the left, a code editor shows a JSON configuration for a map grammar. The central part of the interface features a map of a coastal area with a semi-transparent control panel overlaid. This panel includes a search icon, a list of data layers with checkboxes, and sliders for adjusting the opacity of selected layers. On the right side, there are two data plots. The top plot, titled 'AirTemp', shows a line graph of 'stations_abstract' (y-axis, 0-20) versus 'stations_timestep' (x-axis, 0-24). The bottom plot, titled 'T2', shows a line graph of 'T2_abstract' (y-axis, 0-50) versus 'T2_timestep' (x-axis, 0-20). Both plots have a legend on the right side with 'stations_index' and 'T2_index' labels.

```
2- "components": [  
3-   (  
4-     "id": "grammar_map",  
5-     "position": {  
6-       "width": [  
7-         3,  
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83-        ),  
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101-        ),  
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110-        ),  
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127-          }  
128-        )  
129-      )  
130-    )  
131-  )  
132- ]  
133- }
```

Control Panel:

- water
- T2
- LUINDEX
- MODIS_SAT
- RPL_THEME_1
- RPL_THEME_2
- RPL_THEME_3
- RPL_THEME_4
- AirTemp
- WindSpeed

Plot 1 (AirTemp): Y-axis: stations_abstract (0-20), X-axis: stations_timestep (0-24). Legend: stations_index (0-5).

Plot 2 (T2): Y-axis: T2_abstract (0-50), X-axis: T2_timestep (0-20). Legend: T2_index (0-26).

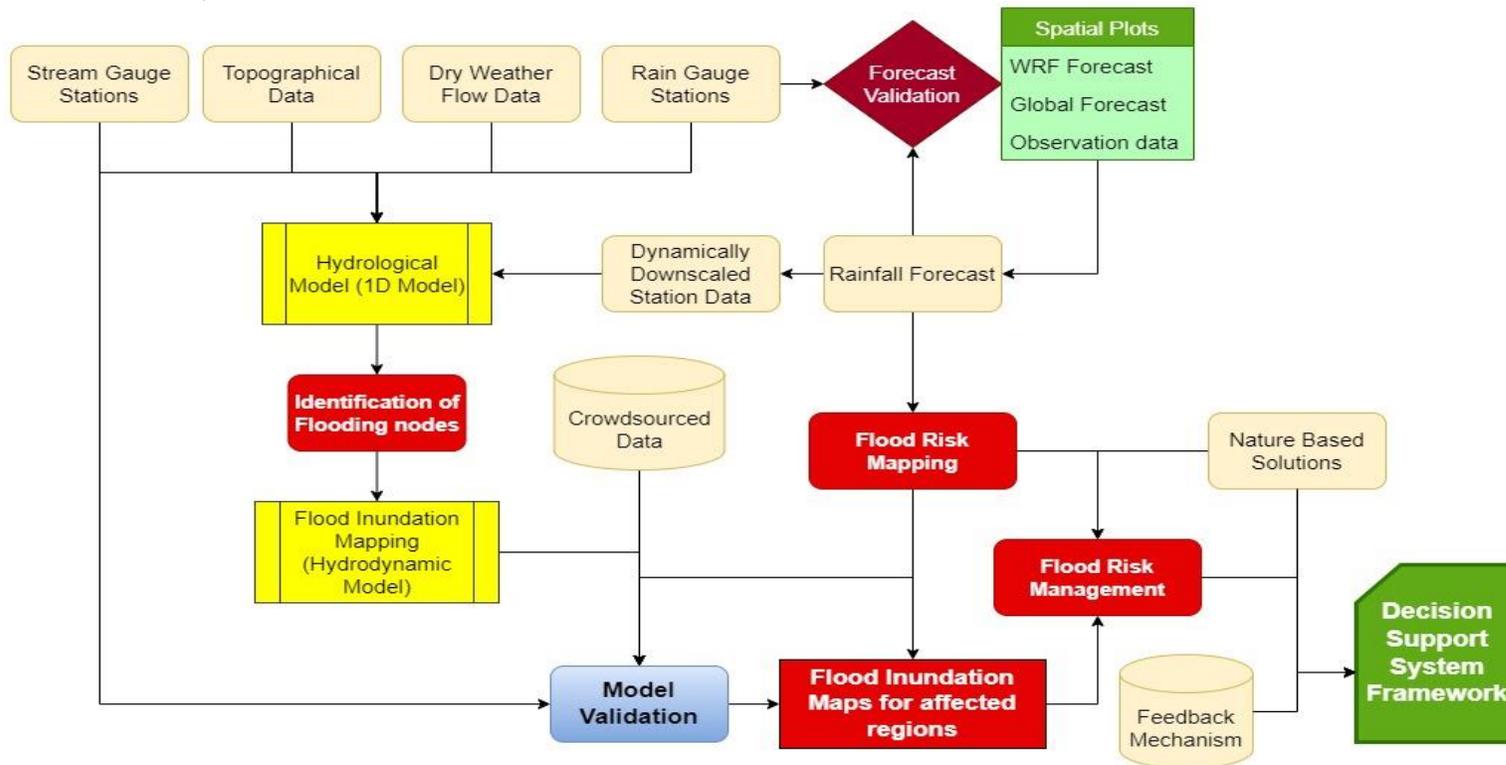
Near Real-time (NRT) Climate/weather products/tools



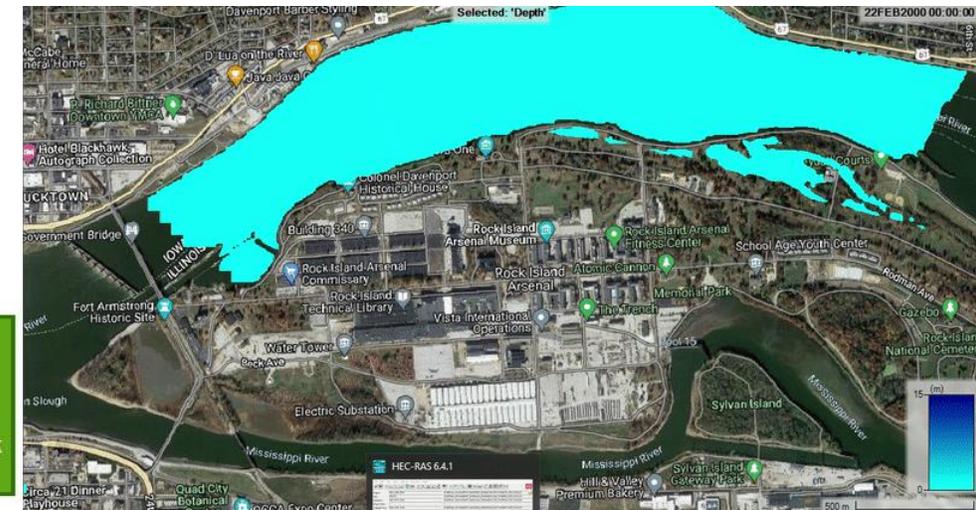
- Weather and Air Quality forecasting
 - 3 to 1 km regional scale
 - 250 m to 100 m to street-level forecasting (~m scales)
- Environmental justice (EJ) toolkit
- EJ toolkit + machine learning street-scale weather and air quality forecasting

Urban Flood Forecasting Model

- Develop a high-resolution coupled hydrodynamic model to visualize flood propagation, identifying fine-scale flooding scenarios.
- Decision support system for early warning flood forecast system
- Engineered and nature-based solutions to mitigate flooding in urban cities.



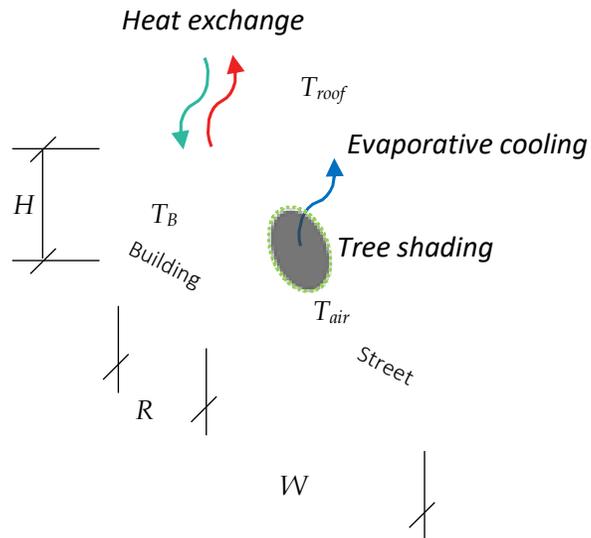
Early simulation of flood inundation maps – flood propagation in the Chicago Region



Few flagship projects!

Helping utilities plant trees and avoid grid failures

Modeling sketch



Metrics

- Cooling/heating degree days
- Heat mitigation efficiency
- PMV thermal comfort index

Scenario 1:

Two row
Densely vegetated



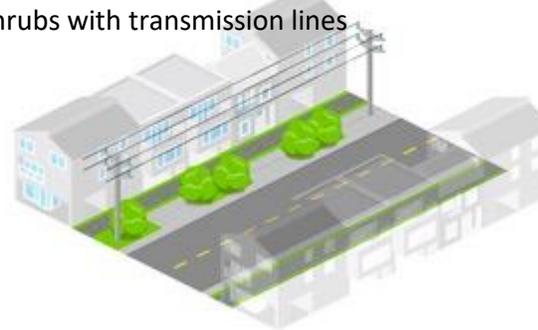
Scenario 2:

One row
Tall trees



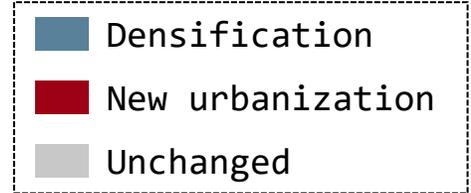
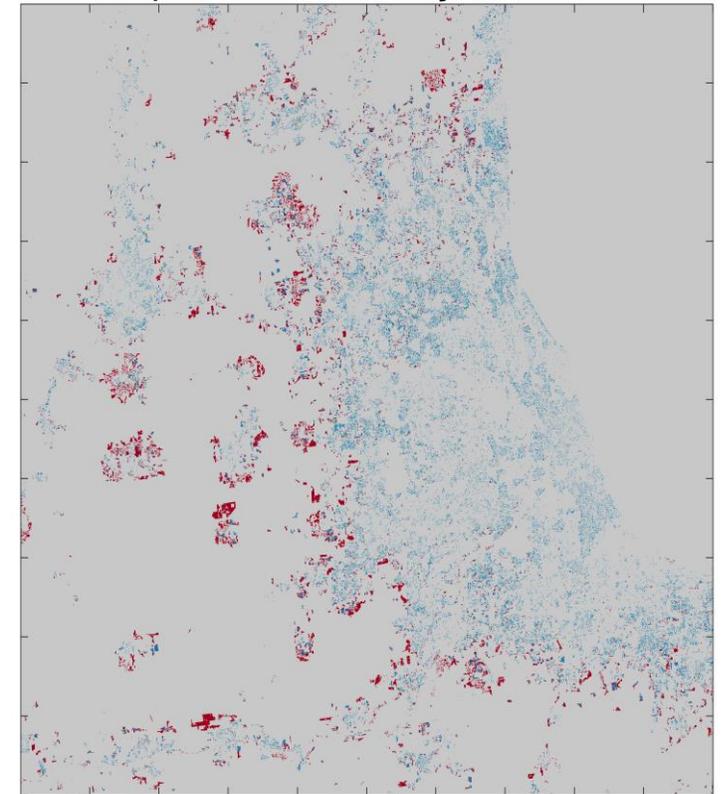
Scenario 3:

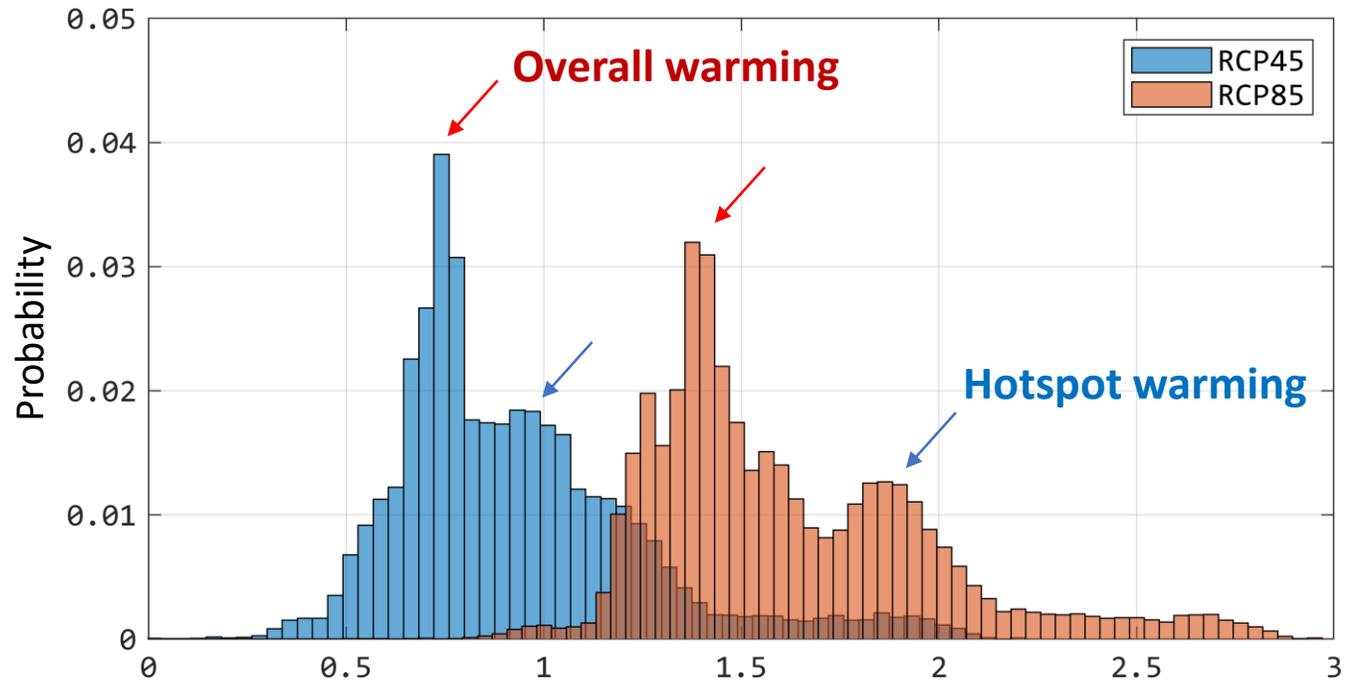
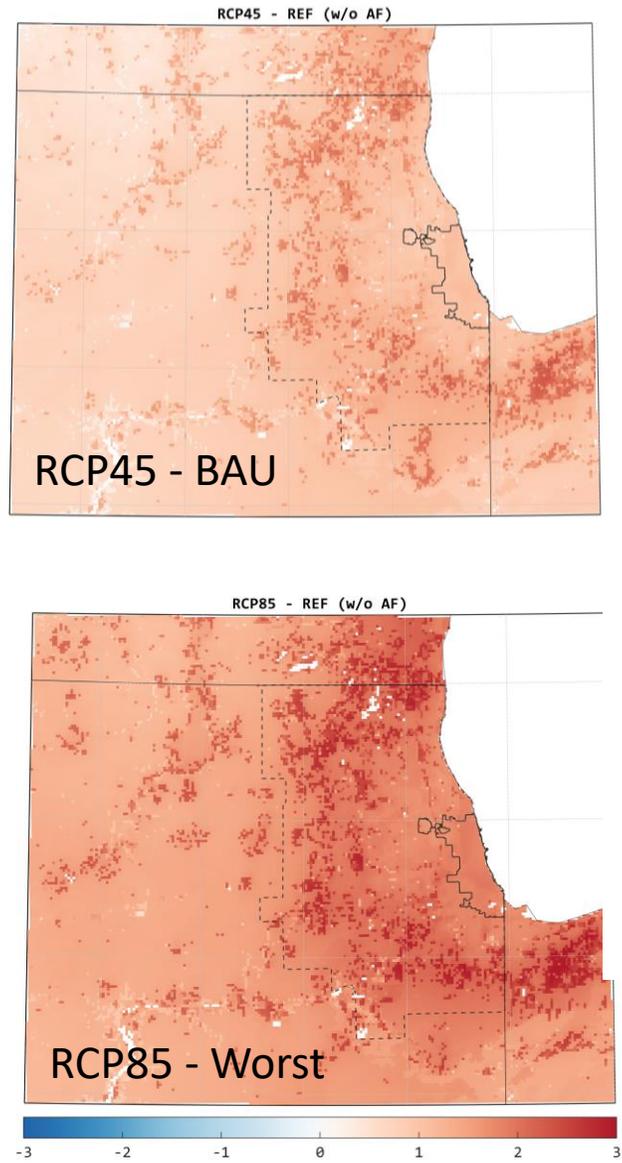
Shrubs with transmission lines



Year 2030 minus year 2020

Development intensity





- Afforestation will mitigate or offset hotspot warming.

Urban science is not just modeling **environmental topics and issues**

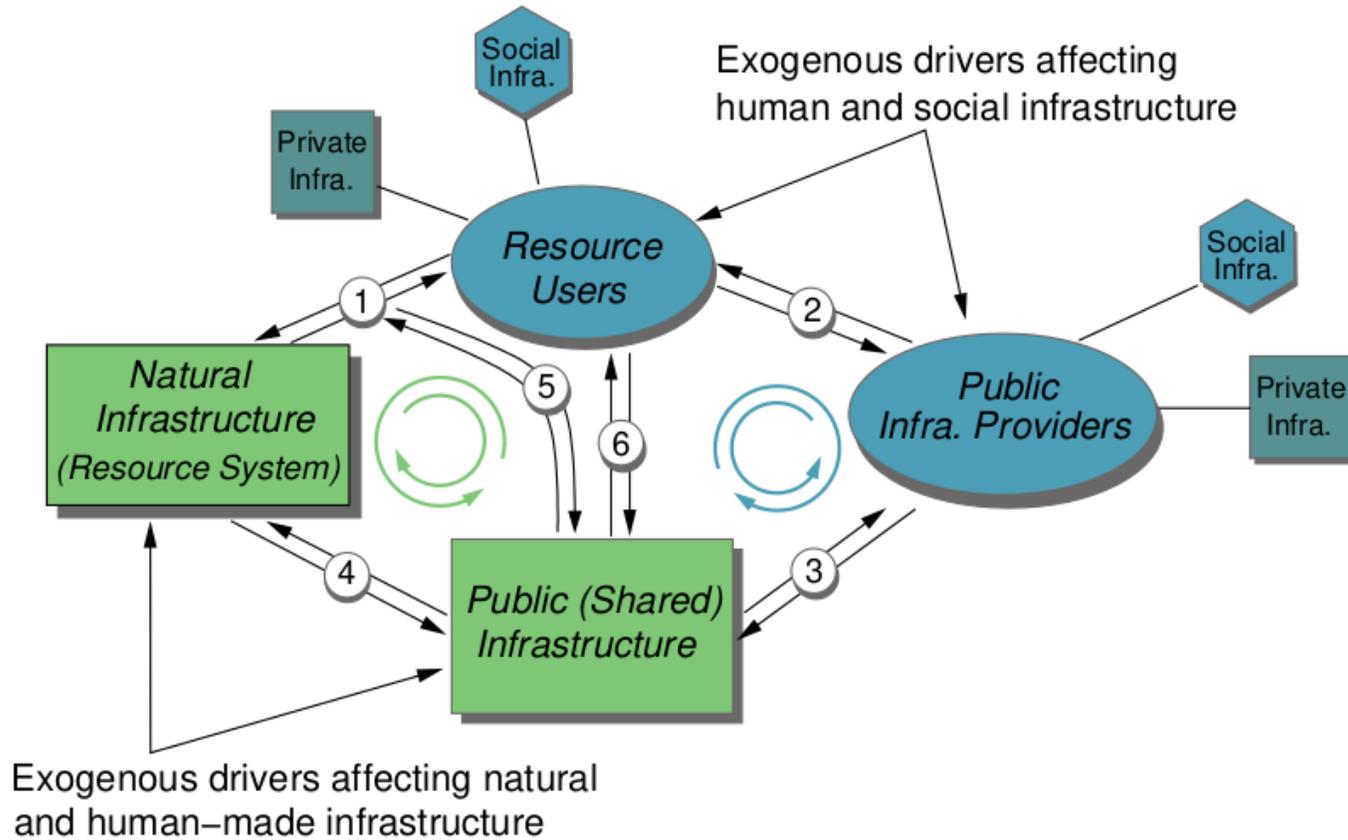
It is also about

other complexities related to societal & infrastructure issues.

We need to address them in an integrated fashion!

Let's see few examples...

Urban Coupled Infrastructure System framework



RU: People who rely on the natural infrastructure to generate livelihoods and well being.

PIP: People who make decisions about how to allocate shared financial resources (e.g. taxes, user fees, etc.) to fund shared infrastructure

PI: Facilities and systems that are collectively owned that transform materials/information. *Hard:* Built environment, e.g. roads, dams, canals. *Soft:* Institutions (formal regulation), norms, legal structures, codified knowledge

NI: Abiotic+Biotic elements and their interactions create ecosystems that support populations of desired species, resource flows (e.g. water, air, minerals etc.).

Working with interdisciplinary scientists...

NSF Partnerships for International Research and Education (PIRE)



Traffic congestion



How can decarbonizing the transportation sector make cities sustainable and resilient?

Heatwave



Air quality

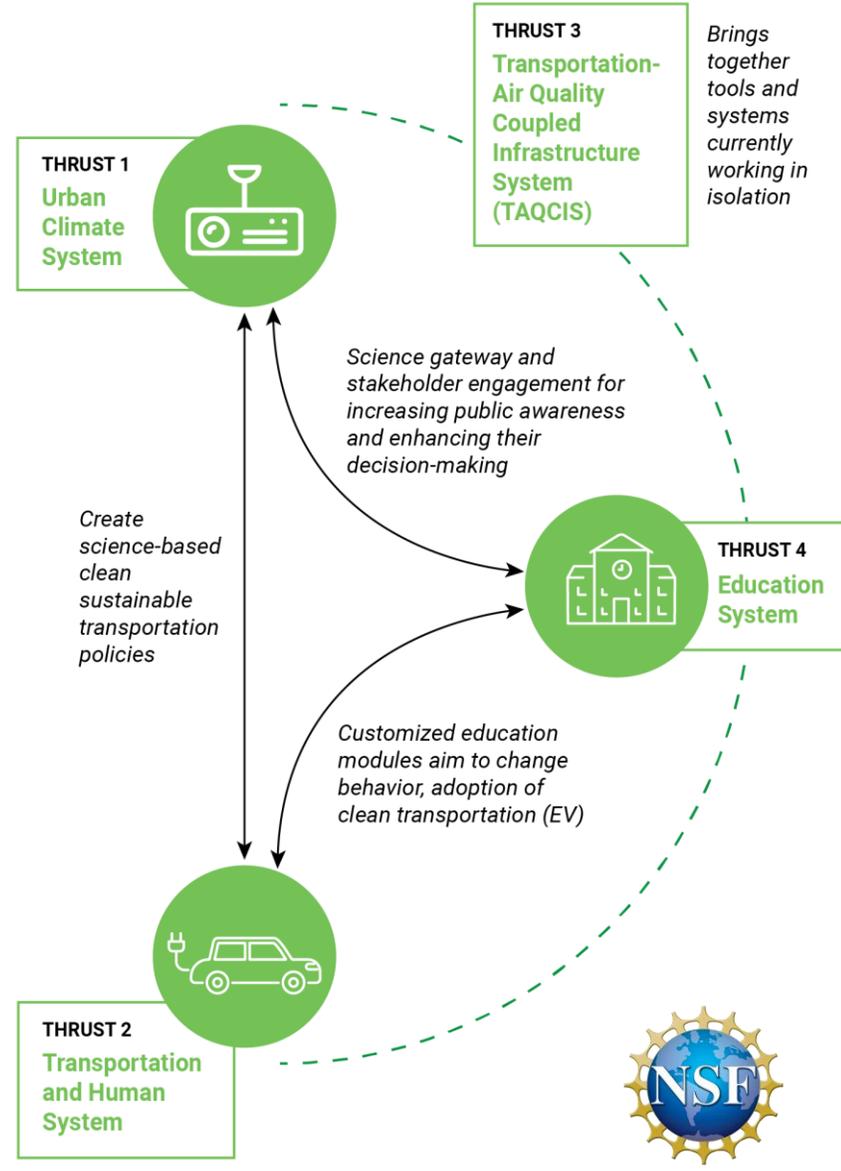
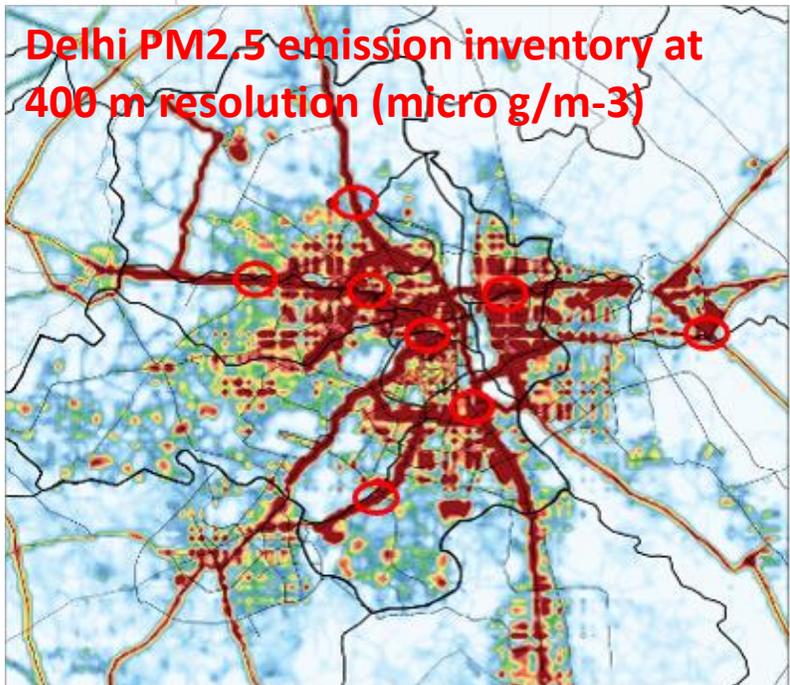
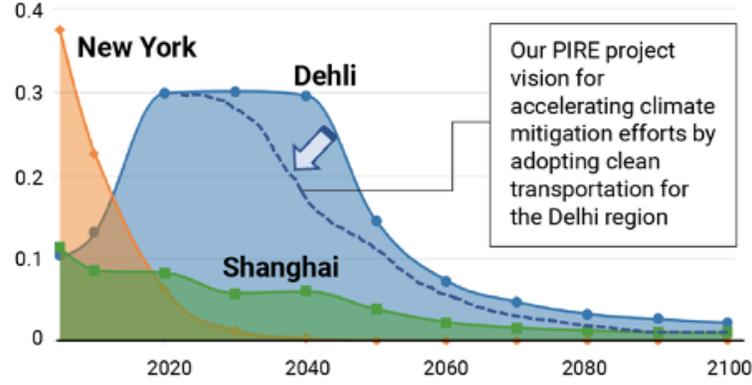


Delhi, Bhuvneshwar, Pune as a testbed

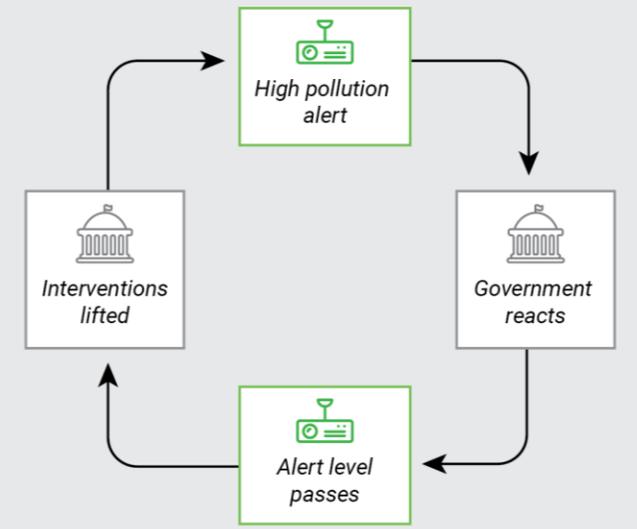
PIRE vision for Convergence Sustainable Urban Research

Accelerating clean transportation and mitigating climate change

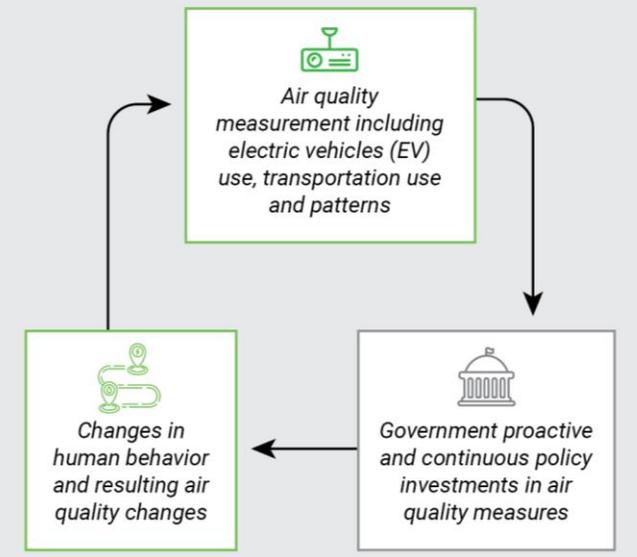
Urban transportation CO emissions (yearly)
Carbon monoxide emissions for RCP8.5 in teragram (Tg) [b]



Current: Air quality management approach
Graded Response Action Plan (GRAP)



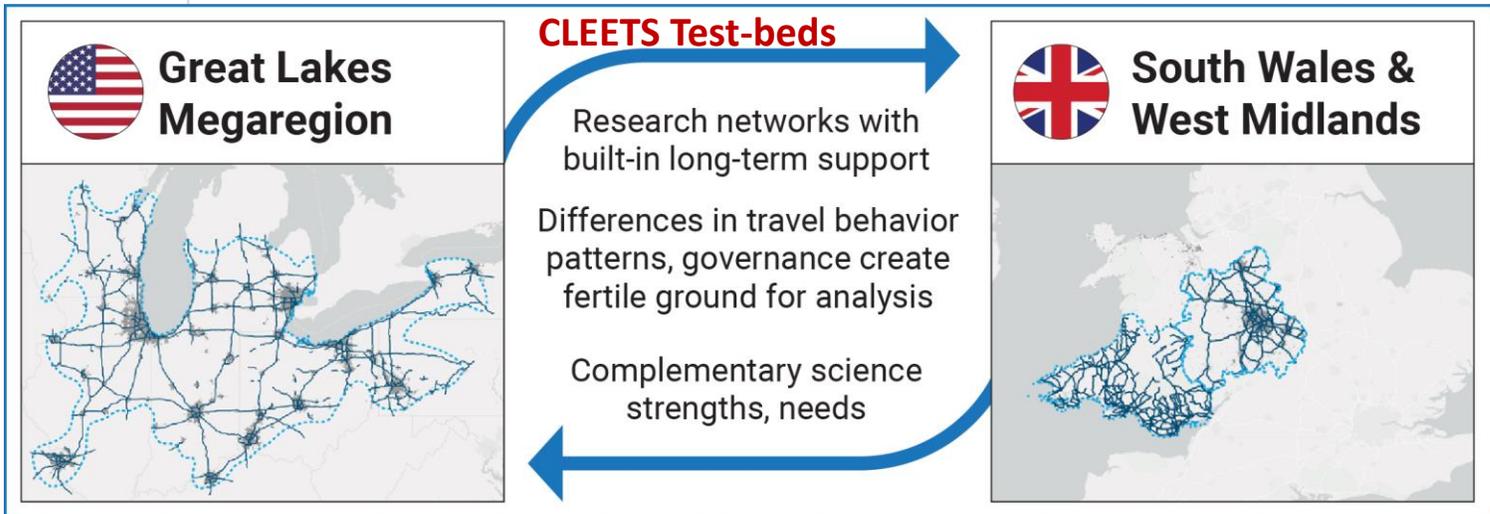
Proposed: PIRE-based proactive system



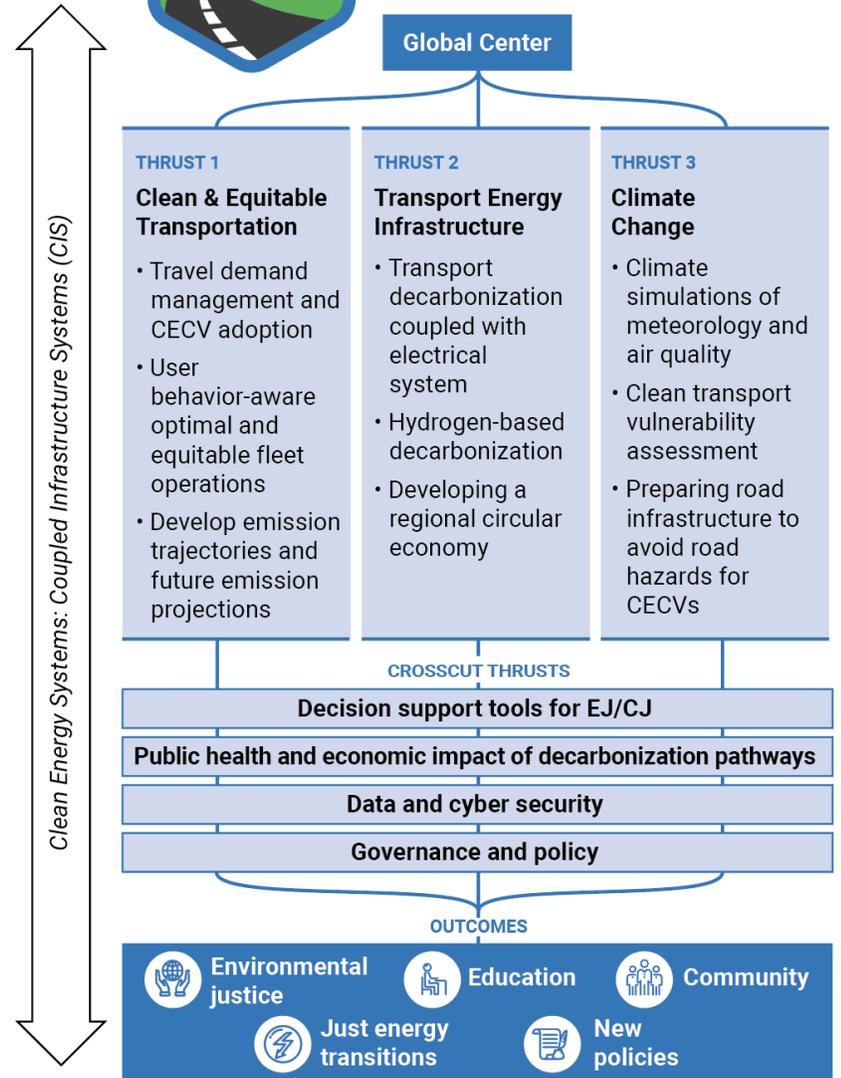


Clean Energy and Equitable Transportation Solutions

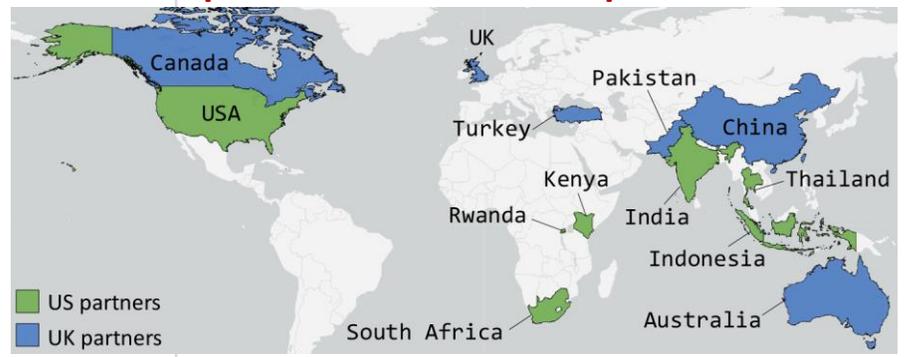
(CLEETS) NSF-UKRI Global Center



CLEETS research plan



CLEETS potential to scale with partners

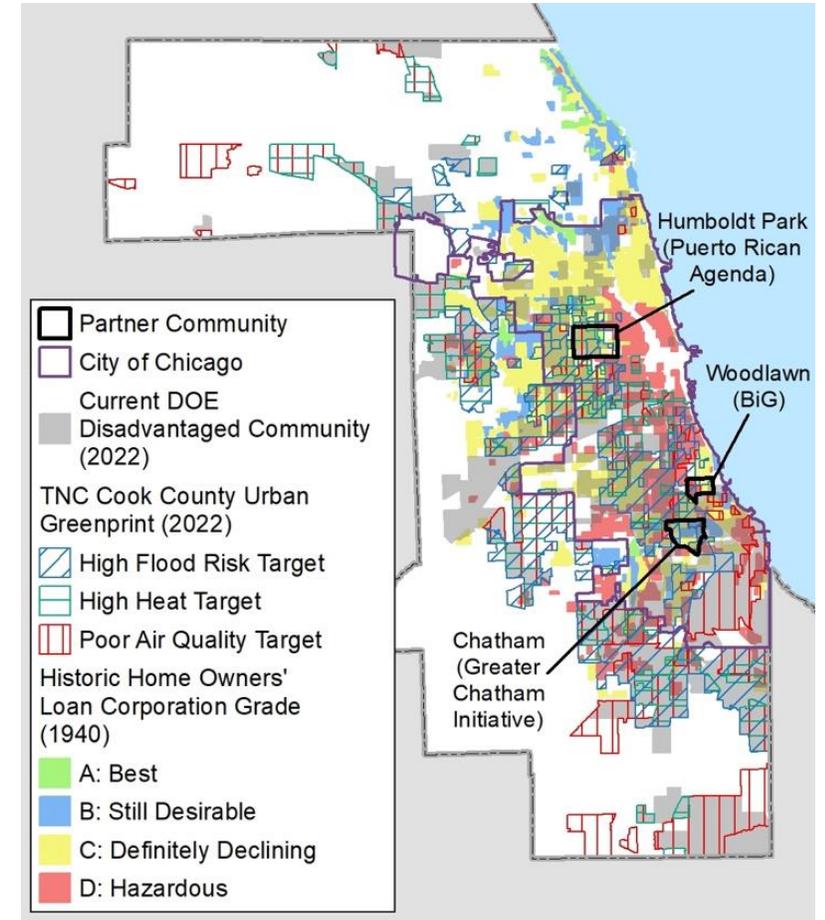


For more information, visit:
<https://www.cleets-global-center.org/>
 @CleetsGlobal and @DPI_Climate



DOE Office of Science: urban integrated field laboratory

- Led by Argonne, with 12 academic and 4 community partners
- 16-County wide study region around Chicago, in three states
- Results specific to the region plus methods that can be used elsewhere
- \$25 million over five years



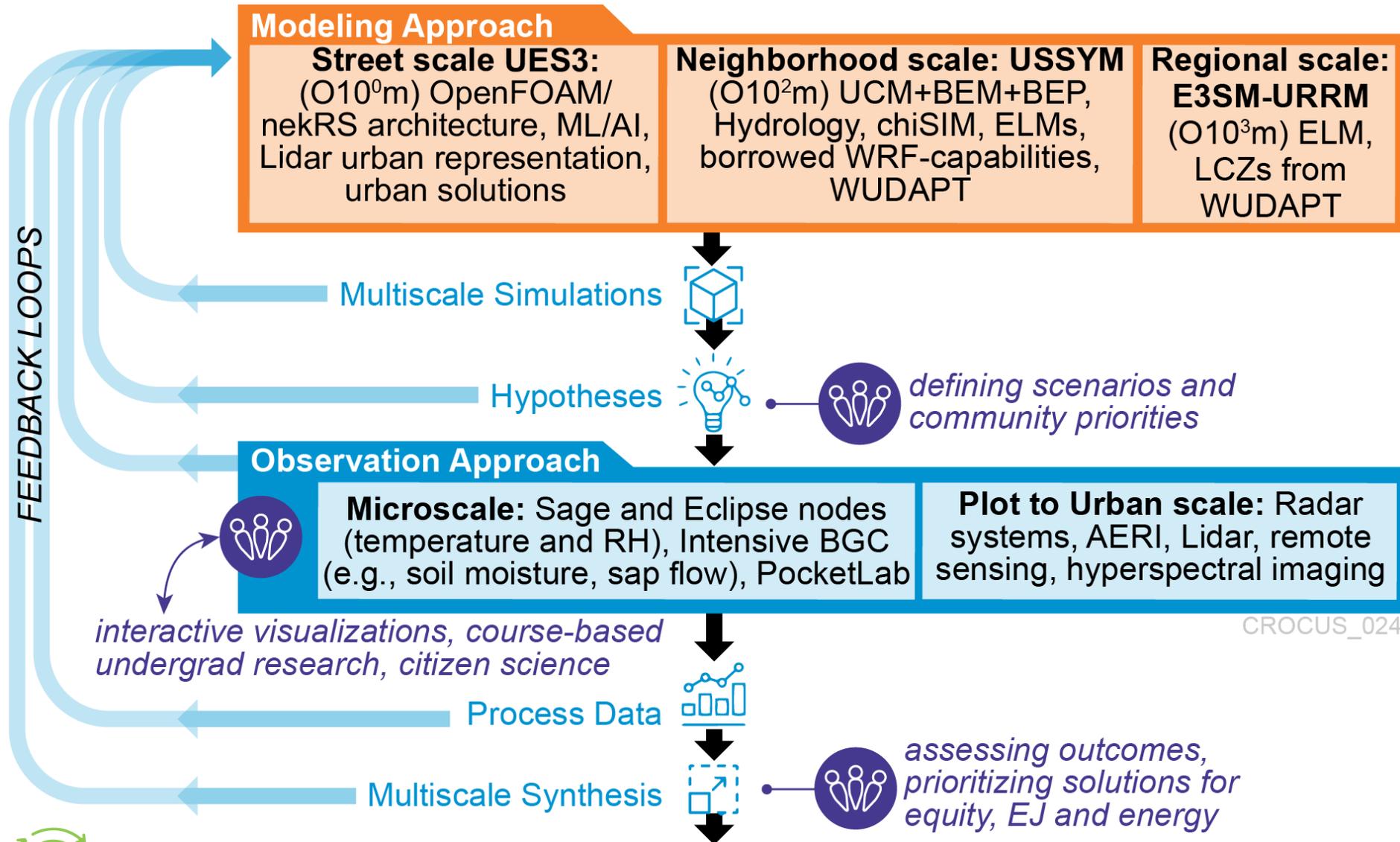
CROCUS

Community Research on Climate & Urban Science

<https://www.anl.gov/crocus>

Climate Science Through the Lens of Community

Addressing Scales in modeling and observations

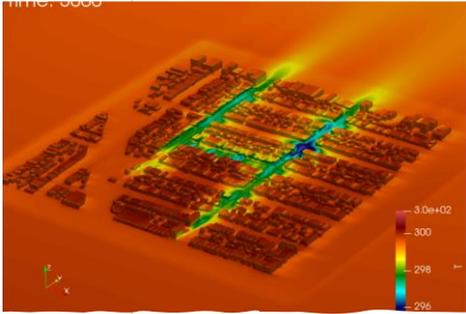


CROCUS_024

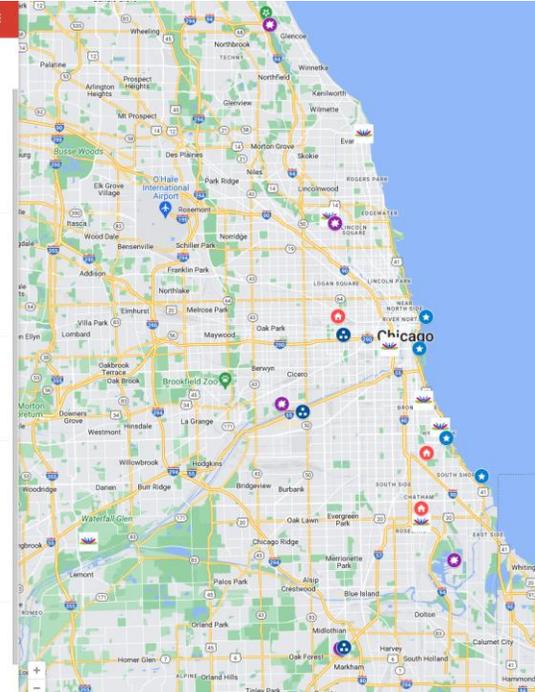


QUANTITATIVE KNOWLEDGE FOR EXTENSIBILITY AND GLOBAL IMPACT

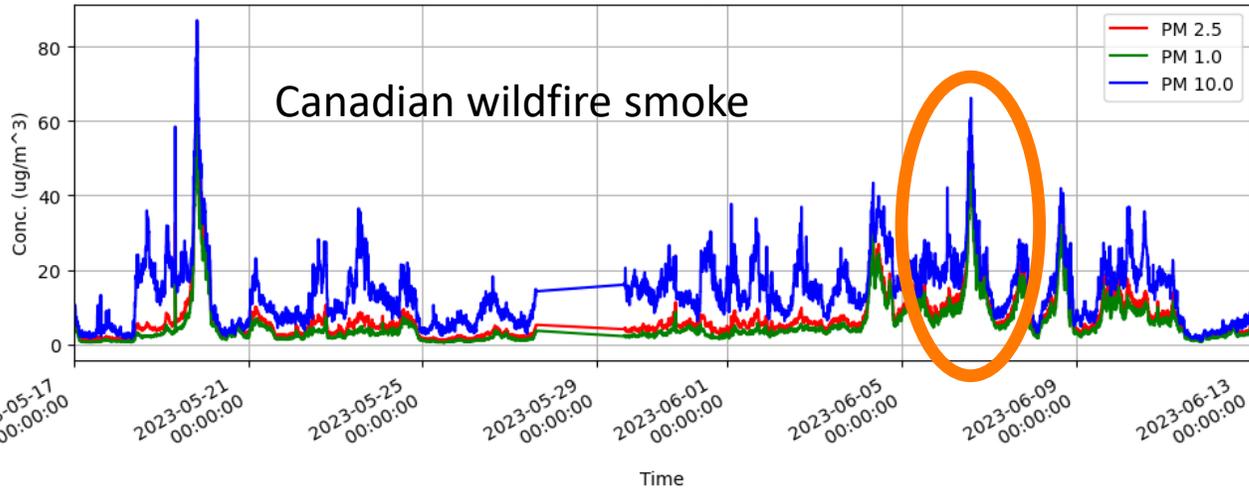
CROCUS Deployment



- CROCUS Locations**
- Initial planned deployments**
 - Chicago State
 - Scott Hall, Northwestern
 - UIC Patio
 - Harper Court
 - NEIU Rooftop
 - ATMOS
 - NEIU CCICS
- Champions**
 - Museum of Science and Industry, Chicago
 - Jardine Water Purification Plant
 - Shedd Aquarium
 - Eugene Sawyer Water Purification Plant
- Community locations**
 - Kells (George) Park
 - The Green Living Room
 - Tuley (Murray) Park
- Other potential sites**
 - Paintbrush Prairie Nature Preserve
 - Fermilab
 - Stickney Water Reclamation Plant
 - Big Marsh Park
 - North Park University - NASA Connection
 - Negaunee Institute for Plant Conservation S...
- NU Current sites**
 - Indian Boundary Prairie
 - Garfield Park Eco-Orchard
 - Academy for Global Citizenship and LeClair...



CROCUS NEIU Node (W08D) - Vaisala AQT-580



Takeaways:

Making cities and communities resilient!!!

Fundamental → Applied → Translational → Collaborative research

- Climate change impacts are **disproportional** in cities.
- **Bridge scale gaps**: regional <—> local <—> hyper-local
- Design tools for **specific science questions** and research needs.
- One solution can't fit all → Need a **mix of solutions**.
- Multi-disciplinary and multi-stakeholder engagements for **actionable research-based**, cost-effective, sustainable solutions.

Thank you!

Ashish Sharma

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Twitter: @A_Sharma007; @DPI_Climate

<https://www.climate-dpi.org/>