

Evaluating the Impact of Urban Trees on the Thermal Comfort in Imola, Italy and Tempe, USA

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²School of Arts, Media, and Engineering, Arizona State University, United States of America



Ph.D. Program of Health, Safety, and Green systems

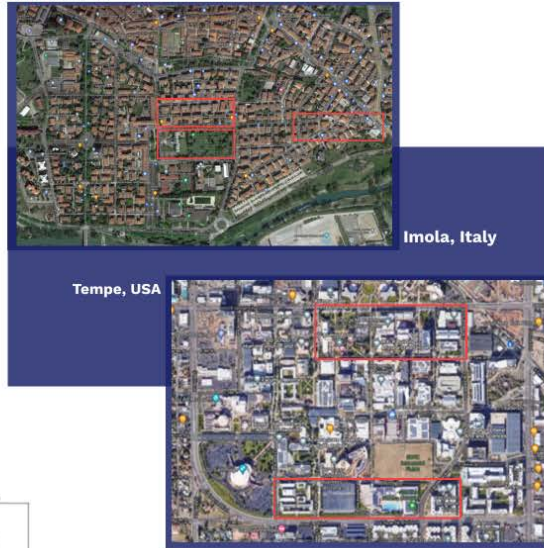
Introduction

- As tree planting has become a priority for many cities around the globe to combat urban heat, **the need to optimize tree placement for maximum cooling benefits** has increased due to limited resources.
- Yet, modeling neighborhood micro-climate at high spatial resolution models that simulate air temperature, wind flow, and radiant fluxes in complex urban settings is **time-consuming and requires extensive computing power.**

Objectives

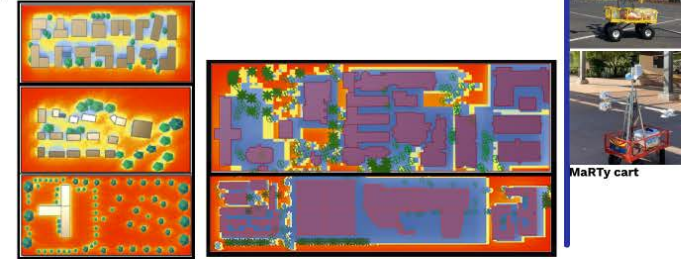
- Introducing a **Python-enhanced** hybrid approach for simulating the **diurnal impact** of street trees on **Mean Radiant Temperature (MRT)** and **thermal comfort** (Universal Thermal Comfort Index, UTCI) based on a 3D model in **Rhino, EnergyPlus, and Ladybug** components in grasshopper.
- Mapping spatial variations of the MRT by the presented model to assess the effects of trees in **different climates and urban forms** in the cities of **Imola, Italy** and **Tempe, USA.**

Case study



Results

The model was tested in two contrasting climates: **hot and humid** Imola, Italy, and **hot and dry** Tempe, Arizona, USA. Results show that building shade has impressively helped the Tempe to decrease the MRT, while in Imola, low building density creates less shaded area and it impacted the MRT in most of the area.



Spatial variations in MRT on the June 9th, at 3PM at the micro-scale in the cities of Imola, Italy (left) and Tempe, USA (right)

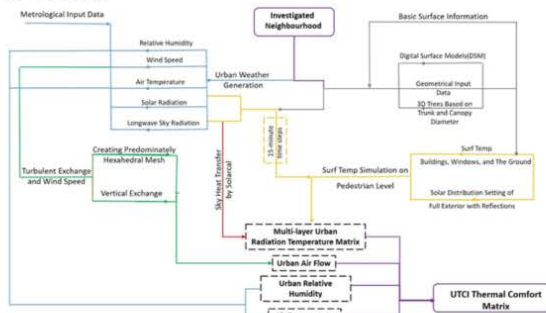
Conclusion

This model is a cohesive approach that minimizes miscalculation by employing **various engines** and using the output of one step as input for the next step in an integrated fashion.

It uses an accurate **3D model of geometric** properties of buildings and trees.

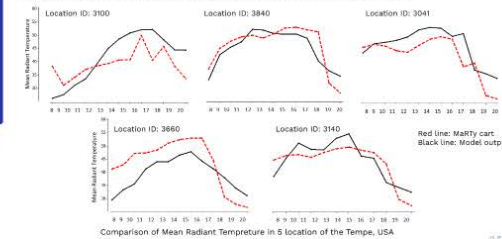
The **hierarchical structure** of the proposed model not only enables it to overcome the issues of previous models regarding modeling thermally comfortable urban environments, but also makes it **faster**, more accurate, and higher in quality by combining various, highly efficient engines into an integrated set of **3D visualization and mapping methods.**

Methodology



Validation

Model output for Tempe **was validated** for hot summer days in June 2018 through human bio-meteorological observations at select locations on Arizona State University's Tempe campus using the **MaRTy cart**.



Comparison of Mean Radiant Temperature in 5 location of the Tempe, USA

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Introduction

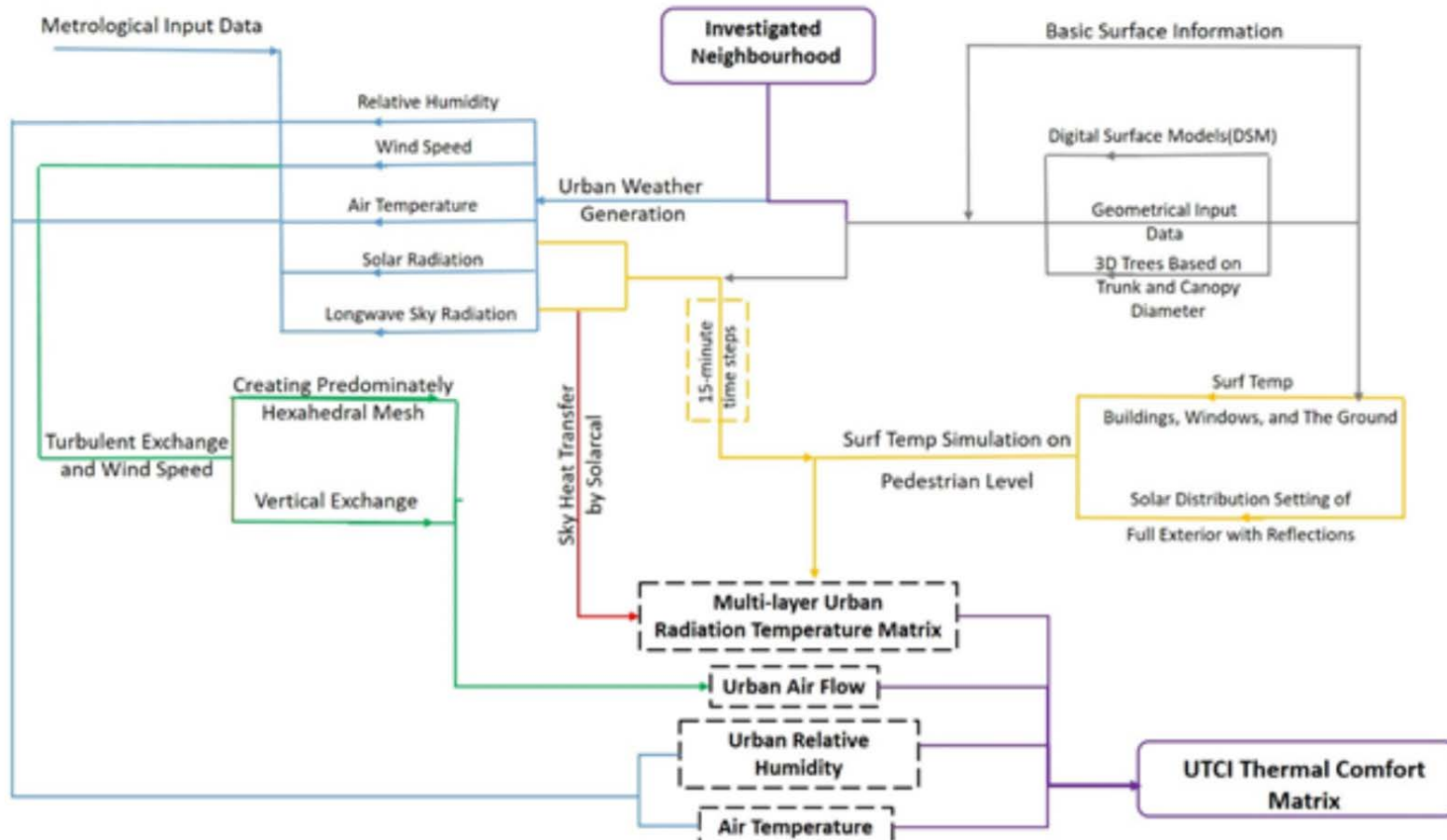
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Methodology

Methodology



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Mean Radiant Temperature

60
55
50
45
40
35
30

Case study



Imola, Italy

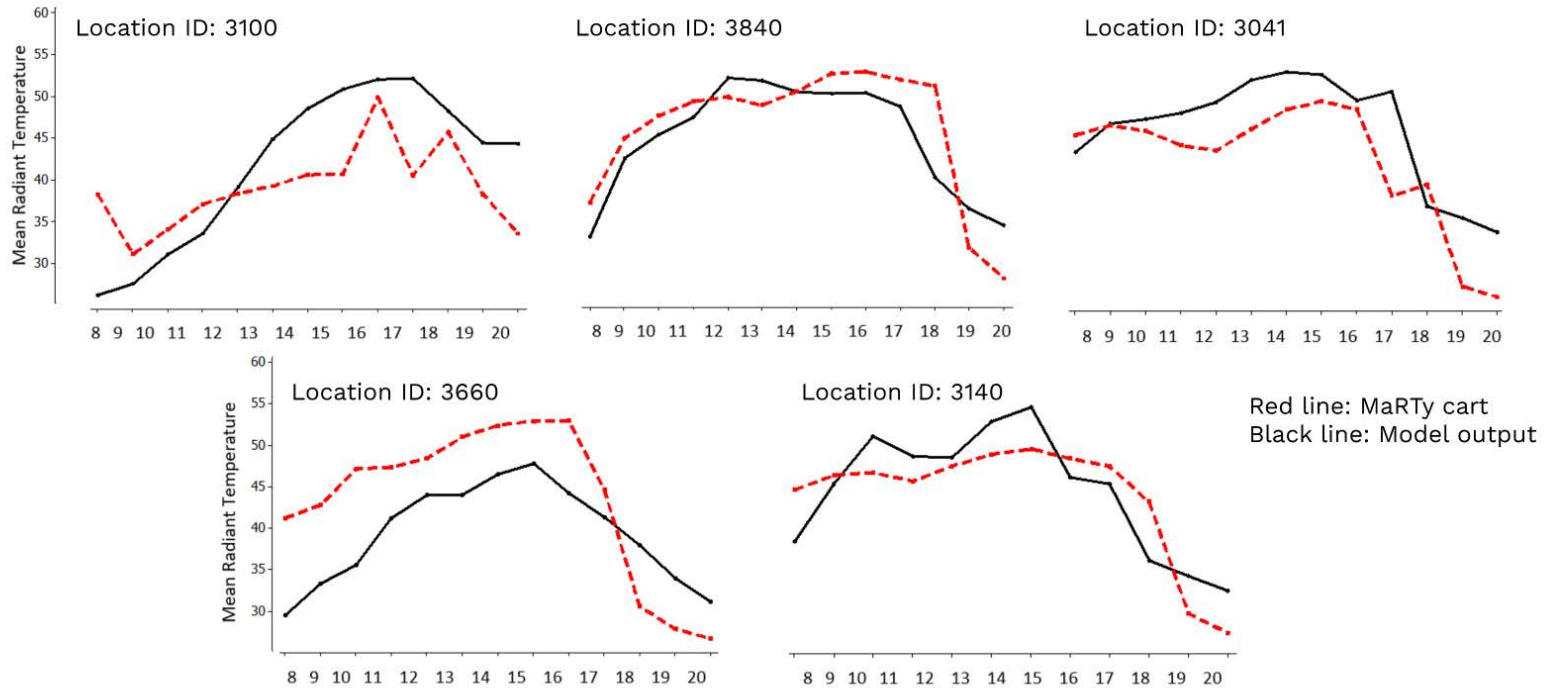
Tempe, USA





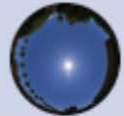

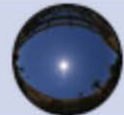


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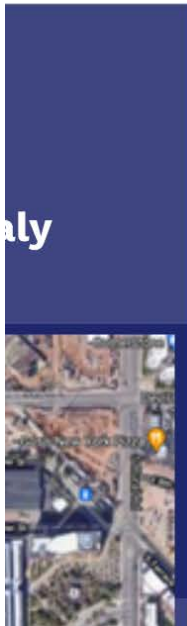
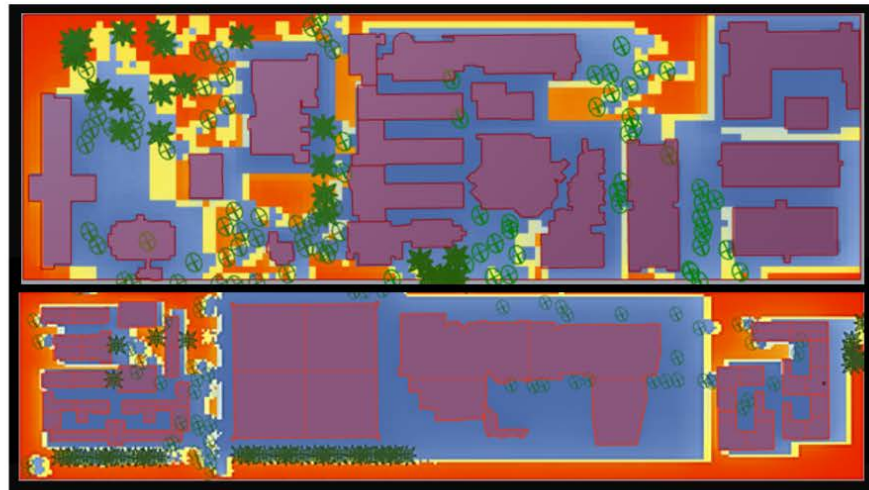
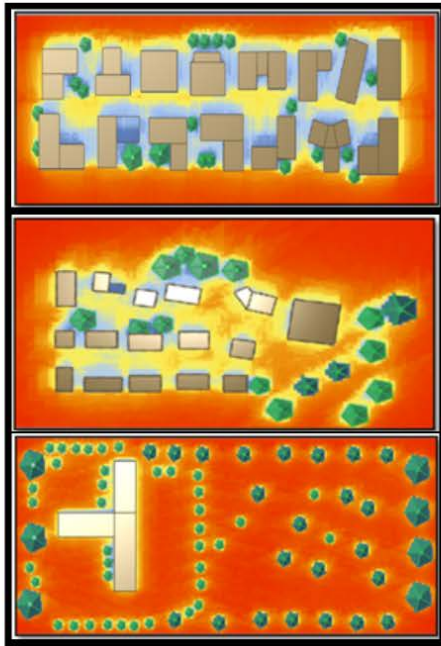
ID	Fisheye Photo	Shade Type	Tree Species	Ground Surface	Albedo (12:30 LST)	SVF	360° sky fraction	360° tree fraction	360° building fraction	360° imperv. fraction	360° perv. fraction
3100		exposed	-	imperv.	0.20	0.8393	0.2182	0.0988	0.1498	0.1905	0.3410
3840		building canyon	-	imperv.	-	0.5138	0.0866	0.1681	0.2788	0.4534	0.0009
3041		exposed	-	imperv.	0.21	0.7681	0.1796	0.1343	0.2281	0.3876	0.0608
3660		PV canopy	-	imperv.	-	0.0415	0.0208	0.0585	0.4072	0.4714	0.0001
3140		exposed	-	imperv.	0.17	0.8653	0.2587	0.2669	0.0438	0.3788	0.0389

Time	3660		3140		3100		3840		3041	
9 Jun 2018	EP	MaRTy	EP	MaRTy	EP	MaRTy	EP	MaRTy	EP	MaRTy
8 AM	27.10	41.43	41.17	46.94	60.37	64.13	39.64	55.76	-	-
9 AM	28.80	32.95	54.37	57.63	66.64	66.22	44.81	57.93	52.48	63.46
10 AM	32.87	36.49	58.29	61.45	67.51	64.97	47.95	64.00	64.71	66.54
11 AM	35.86	40.05	61.23	63.85	69.02	61.80	55.64	64.22	74.73	67.10
12 PM	42.55	41.55	67.76	64.57	71.37	60.63	59.57	65.70	70.47	65.26
13 PM	49.27	42.60	67.36	63.22	76.23	65.40	59.56	69.24	70.26	68.46
14 PM	53.57	44.21	65.44	65.54	77.95	69.69	63.10	71.15	77.81	70.90
15 PM	56.31	44.36	65.23	68.50	77.40	71.61	64.88	71.89	80.94	72.05
16 PM	57.78	55.14	65.26	68.80	71.78	69.79	59.95	71.94	66.13	70.07
17 PM	57.81	44.10	62.93	67.52	73.72	50.60	55.93	60.45	64.70	68.42
18 PM	53.28	50.23	51.15	66.46	48.26	53.19	51.20	41.04	48.45	60.96
19 PM	48.71	41.43	45.92	39.21	45.82	30.69	45.67	37.29	45.19	37.34
20 PM	48.61	35.82	43.06	34.20	42.66	28.26	41.85	35.64	42.19	33.31
RMSE	8.54829		6.141		10.40103		10.32038		7.44776	

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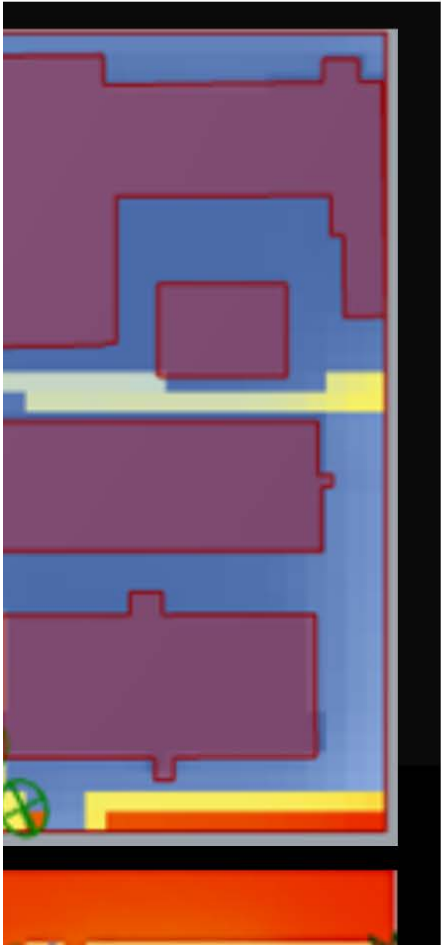
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MaRTy cart

DyD





MaRTy cart

(left) and Tempe, USA (right)

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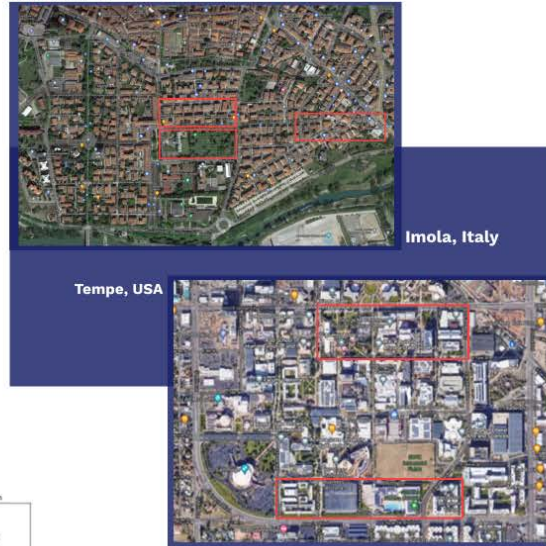
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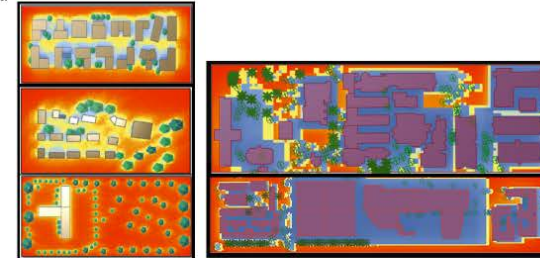
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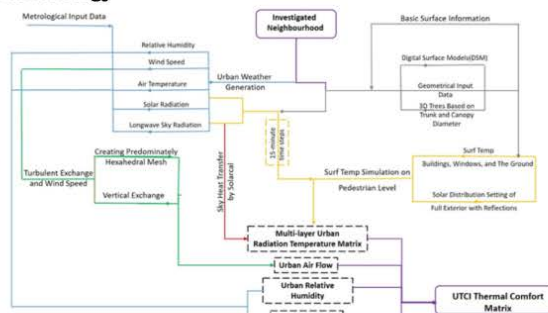
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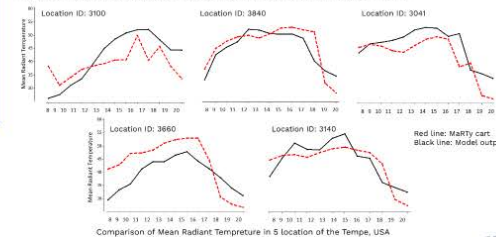
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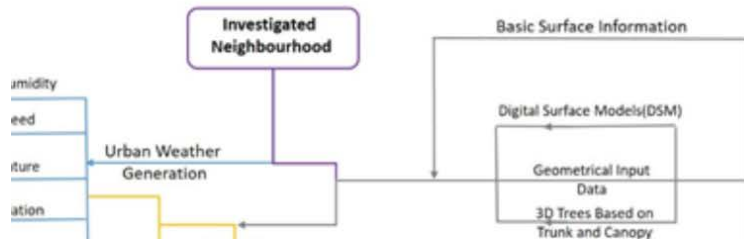
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Imola, Italy

Tempe, USA



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