Designing Cooler Cities

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The session will begin shortly.
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Have a question for presenters? Click the icon.
Aldo Brandi
Ph.D. Candidate, Arizona State University
@aldobrandi5

Influence of Projected Climate Change, Urban Development and Heat Adaptation Strategies on End of Twenty-First Century Urban Boundary Layers Across the Conterminous US

Aldo Brandi*, Ashley Broadbent*, Scott E. Krayenhoff**, Matei Georgescu*
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** University of Guelph – School of Environmental Sciences
Introduction Heat in the Atmosphere

- The atmosphere is mostly transparent to short wave solar radiation.
- The Earth surface emits long wave radiation as a function of its temperature.
- Greenhouse gases (GHG; H₂O, CO₂, CH₄) absorb and re-emit long wave radiation in the atmosphere.

Modified from Krayenhoff et al., 2021
Introduction The Planetary Boundary Layer

“... is that part of the troposphere that is directly influenced by the presence of the earth’s surface” (Stull, 1988)
Introduction The Greenhouse Effect

Increase in GHG concentration
  →
Global Warming
  →
Climate Change
Introduction  The Greenhouse Effect

Increase in GHG concentration
  →
Global Warming
  →
Climate Change

From https://twitter.com/DrShepherd2013, 2021
Introduction The Greenhouse Effect

Increase in GHG concentration

↓

Global Warming

↓

Climate Change

From https://www.nasa.gov/
Introduction  Climate Change Impacts

Heat Waves

- ↑ Intensity
- ↑ Frequency
- ↑ Length

From Broadbent et al. 2020
Introduction Urban Environments
Introduction A matter of scale

Climate Change
Global
Mitigation
(emission reduction)

Urban Heat
Local
Adaptation
(impact reduction)
Main goals:

- Reducing heat absorbed by surfaces by shading or reflection
- Using evapotranspiration processes of plants to absorb part of surface heat and “store” it into water vapor

Modified from Krayenhoff et al., 2021
**Introduction**

**Heat Adaptation**

**Cool Roofs**
- Increase Reflectivity

**Green Roofs**
- Increase Evapotranspiration

**Street Trees**
- Shading + Evapotranspiration

---

From Liu and Chui, 2019

From Livesley et al., 2016

From Al-Obaidi et al., 2014
Introduction Why this is important

More mixing
More Pollutant dilution
Less exposure

Less Mixing
Less Pollutant Dilution
More Exposure

Strong Convection

Weak Convection

No adaptation
Heat adaptation
Introduction  Why this is important
Some Physics
The Urban Boundary Layer (UBL)

Thermal anomalies

+ Anthropogenic heat
  human metabolism, transportation, manufacturing, heating/cooling systems

+ Paved impervious surfaces
  ↑ heat storage  >> ↑ sensible heat (Q_H)
  ↓ soil moisture  >> ↓ latent heat (Q_E)
  ↓ sky view factor  >> ↑ canyon trapping and venting

Aerodynamic anomalies

+ Building 3D morphology
  ↑ roughness length (z_0)
  ↑ zero-plane displacement (z_d)
The Urban Boundary Layer (UBL)

Thermal anomalies

+ **Anthropogenic heat**
  human metabolism, transportation, manufacturing, heating/cooling systems

+ **Paved impervious surfaces**
  
  - up: heat storage $\rightarrow$ up: sensible heat ($Q_H$)
  - down: soil moisture $\rightarrow$ down: latent heat ($Q_E$)
  - down: sky view factor $\rightarrow$ up: canyon trapping and venting

Aerodynamic anomalies

+ **Building 3D morphology**
  
  - up: roughness length ($z_0$)
  - up: zero-plane displacement ($z_d$)
Our research question

*What is the expected impact of heat adaptation on the UBL of American cities in the context of projected climate change and urban development?*
Influence of projected climate change, urban development and heat adaptation strategies on end of twenty-first century urban boundary layers across the Conterminous US

Aldo Brandi, Ashley M. Broadbent, E. Scott Krayenhoff & Matei Georgescu

Climate Dynamics (2021) | Cite this article

172 Accesses | 12 Altmetric | Metrics
Analysis domain and case study cities

From Brandi et al. 2021
Data & Methods

**WRF-ARW V3.6**  
w/ Single Layer Urban Canopy Model

**Spatial extent and resolution**  
North America, 20-km grid spacing, 29 vertical levels

**Temporal extent and resolution**  
Contemporary (Climate and Urban Extent) = 2000 - 2009  
Future (Climate and Urban extent) = 2090 - 2099  
3-hourly outputs

**Climate Forcing**  
Contemporary = ECMWF ‘Era Interim’ Reanalysis  
Future = CESM CMIP5 – RCP 8.5

**Land Cover**  
EPA ICLUS 1.3.2 A2 SRES Scenarios (2010 and 2100)  
3 Urban Classes - ICLUS 31, 32, 33
**Data & Methods**

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w/ Single Layer Urban Canopy Model

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---

**Full Adaptation Scenario**
A combination of individual adaptation strategies

**Cool Roofs**
.88 albedo, uniformly applied on all roofs in the Contiguous US

**Green Roofs**
Evaporating surfaces with unlimited water availability, uniformly applied on all roofs in the Contiguous US

**Street Trees**
2.0 m² m⁻² Canyon Mean Leaf Area, distributed evenly between heights 2.5 and 7.5 m in streets of all urban classes
Data & Methods

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w/ Single Layer Urban Canopy Model

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More detailed information can be found in:

Data available at:
https://dataverse.asu.edu/dataverse/USRegClimateChgAssess
Georgescu, Matei; Brandi, Aldo; Broadbent, Ashley; Krayenhoff, Scott (2021) "2090-2099 Projected Climates and Urban Development Scenarios - Conterminous U.S. (CONUS) Simulation Data", https://doi.org/10.48349/ASU/3TYXZI, ASU Library Research Data Repository, V1
Results (JJA - 14:00 MST)

Urban Development (ICLUS 2100 – 2010)

- UBL Depth (PBLH)
- Sensible Heat Flux (HFX)
- Latent Heat Flux (LH)
- Ground Heat Flux

Greater changes in Eastern CONUS

Climate Change exacerbates Urban Development impacts

Transition from arid to urban landscapes (California)

From Brandi et al. 2021
**Results** (JJA - 14:00 MST)

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Transition from arid to urban landscapes (California)

---

From Brandi et al. 2021
Urban Development + Climate Change are expected to increase Urban Boundary Layer Depth.
Our research question

What is the expected impact of heat adaptation on the UBL of American cities in the context of projected climate change and urban development?
Results (JJA - 14:00 MST)

Full Adaptation
Cool R. + Green R. + Street Trees

▼ UBL Depth (PBLH)
Results (JJA - 14:00 MST)

**Full Adaptation**
Cool R. + Green R. + Street Trees

- UBL Depth (PBLH)
- Sensible Heat Flux (HFX)

From Brandi et al. 2021
Results (JJA - 14:00 MST)

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Climate Change and Urban Development impacts sum linearly

From Brandi et al. 2021
Results (JJA - 14:00 MST)

Full Adaptation
Cool R. + Green R. + Street Trees

Climate Change and Urban Development impacts sum linearly

Full Adaptation UBL reduction exceeds UD and CC increases

From Brandi et al. 2021
Results (JJA - 14:00 MST)

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Cool R. + Green R. + Street Trees

- UBL Depth (PBLH)
- Sensible Heat Flux (HFX)
- Latent Heat Flux (LH)
- Ground Heat Flux

Climate Change and Urban Development impacts sum linearly

Full Adaptation UBL reduction exceeds UD and CC increases

Greater impacts inland
Lesser in coastal cities

From Brandi et al. 2021
Heat Adaptation Strategies are expected to decrease Urban Boundary Layer Depth.
Results (JJA - 14:00 MST)
ICLUS 2100 + CESM RCP8.5 2090-2099

**Full Adaptation**
Cool Roofs + Green Roofs + Street Trees

**New York City**

**Los Angeles + San Diego**

From Brandi et al. 2021
Results (JJA - 14:00 MST)
ICLUS 2100 + CESM RCP8.5 2090-2099

Full Adaptation
Cool Roofs + Green Roofs + Street Trees

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ICLUS 2100 + CESM RCP8.5 2090-2099

Full Adaptation
Cool Roofs + Green Roofs + Street Trees

New York City

Los Angeles + San Diego

From Brandi et al. 2021
Heat Adaptation Strategies are expected to increase Static Stability
Results (JJA - 14:00 MST)
ICLUS 2100 + CESM RCP8.5 2090-2099

Full Adaptation
Cool Roofs + Green Roofs + Street Trees

Los Angeles + San Diego

Peak Values

UBL Depth change
Δ ≅ −100 m

Sensible Heat change
ΔHFX ≅ −160 W/m²

Latent Heat change
ΔLH ≅ 50 W/m²

From Brandi et al. 2021
**Results** (JJA - 14:00 MST)
ICLUS 2100 + CESM RCP8.5 2090-2099

Full Adaptation
Cool Roofs + Green Roofs + Street Trees

Los Angeles + San Diego

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**Peak Values**

- UBL Depth change
  \[ \Delta \approx -100 \text{ m} \]

- Sensible Heat change
  \[ \Delta H_{FX} \approx -160 \text{ W/m}^2 \]

- Latent Heat change
  \[ \Delta L_{H} \approx 50 \text{ W/m}^2 \]

From Brandi et al. 2021
**Results** (JJA - 14:00 MST)
ICLUS 2100 + CESM RCP8.5 2090-2099

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From Brandi et al. 2021
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**Full Adaptation**
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**New York City**

Peak Values

- **UBL Depth change**
  \[ \Delta \approx -180 \text{ m} \]

- **Sensible Heat change**
  \[ \Delta \approx -60 \text{ W/m}^2 \]

- **Latent Heat change**
  \[ \Delta \approx 0 \text{ W/m}^2 \]

From Brandi et al. 2021
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From Brandi et al. 2021
Background Climates modulate Urban Development, Climate Change and Heat Adaptation Impacts on UBL dynamics.
Conclusions  (Brandi et al. 2021)
Conclusions  (Brandi et al. 2021)

- **Urban Development** (ICLUS 2100) and **Climate Change** (RCP8.5) are expected to **increase UBL depth** by tens of meters
  - Impacts are greater in the eastern part of CONUS
Conclusions  (Brandi et al. 2021)

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Conclusions  (Brandi et al. 2021)

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  - Heat Adaptation impacts are greater inland and weaker over coastal cities
  - In Southern California, adaptation induced latent heat increase may counterbalance sensible heat reduction impacts on UBL depth
Conclusions  (Brandi et al. 2021)

- **Urban Development** (ICLUS 2100) and **Climate Change** (RCP8.5) are expected to **increase UBL depth** by tens of meters.
  - Impacts are greater in the eastern part of CONUS.

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- **Heat Adaptation strategies** are expected to **increase both daytime and nighttime static stability** near the surface.

- **Background Climates modulate** Urban Development and Heat Adaptation impacts on UBL dynamics:
  - Heat Adaptation **impacts are greater inland** and weaker over coastal cities.
  - In Southern California, adaptation induced latent heat increase may counterbalance sensible heat reduction impacts on UBL depth.

Interaction between landscape change and background climate has important consequences on UBL dynamics:

- UBL depth
- Static Stability
- Subsidence

  - Downward compression of convective mixing
  - Potential for higher pollutant concentration at pedestrian level.

Need for thorough **evaluation of tradeoffs between achieving thermal comfort and preserving air quality in urban environments** when designing and implementing landscape modifications.
Thank you

abrandi@asu.edu


Future work

BL instability favors
Upward motion

UHIC ~ Thermal

BL stability favors
Downward motion

Thermal > UHIC

From Oke et al. 2017
Future work

Figure 2. Domain configurations for the MPAS-WRF nested simulations: a) approximate grid spacing for the rotated MPAS 60km-to-3km variable resolution mesh centered at 36.6N, 112W. The bold rectangle indicates the parent WRF (D01) domain. The contour interval is 2km and the value of the innermost contour inside the rectangle is 2km; b) the parent WRF domain (D01) to be driven by MPAS with a grid spacing of 3km. The bold squares indicate the nested WRF domains driven by domain D01; c), d), and e) are the nested WRF domains D02, D03, and D04, centered on Phoenix, Los Angeles and Denver, respectively, with a grid spacing of 1km. The shading in the WRF domains represents terrain elevation in units of kilometers; the filled black circles superimposed in c) - e) denote city centers.
Air quality and Climate Change

More frequent stagnation events ➔ Negative impact on local circulation systems

Projected higher temperatures will increase pollutant concentrations
Increased BVOCs (Biogenic Volatile Organic Compounds) emissions

Ozone (O₃)
Facilitated photodissociation processes
Projected increase in methane (CH₄) concentration might overcome NOₓ reduction

Particulate Matter (PM₂.₅ – PM₁₀)
Increased frequency and duration of wildfires
Persisting drought events ➔ Soil erosion ➔ Dust storms
Air Pollution

Ozone \((O_3)\)

Photodissociation

\[
\text{NO}_2 + h\nu \rightarrow \text{NO} + O \\
O + O_2 + M \rightarrow O_3 + M
\]

Mostly daytime reaction (needs UV radiation)
Favored by higher temperature

Powerful oxidant
Attacks C=C double bonds
abundant in rubber, plants, human body membranes, especially in the lungs and the heart

https://www.sleepaider.com/articles/health-effects-of-ozone-pollution.22/
Air Pollution

Particulate Matter (PM$_{2.5}$ – PM$_{10}$)

Schematic representation of the size distribution of particulate matter in ambient air (USEPA 1996) - "Chapter 7.3 Particulate Matter"
Edith de Guzman
Director and Co-founder, LA Urban Cooling Collaborative
Ph.D. Candidate, UCLA Institute of the Environment and Sustainability
@edithbdeguzman

Cooler and Healthier: Reducing Heat-Health Risk Using Urban Forestry & Stakeholder Engagement
COOLER AND HEALTHIER:
Reducing heat-health risk using urban forestry and stakeholder engagement

September 8, 2021 | UCLA Climate Adaptation Research Symposium

Edith de Guzman | UCLA Institute of the Environment & Sustainability and Los Angeles Urban Cooling Collaborative
What I’ll cover:

1. Urban forests and extreme heat
2. Challenges of urban forest stewardship
3. Behavior change study on urban forest stewardship
4. Preliminary findings
5. Next steps and implications
Urban forests and extreme heat

Hottest day in L.A. County’s recorded history: 121°F on Sept. 6, 2020

Duplex with no trees or AC in Huntington Park: 107.4°F indoors

Could changes we make to the urban environment cool neighborhoods and save lives?
We tested “prescriptions” of

TREE CANOPY

+ SOLAR REFLECTANCE (ALBEDO)

of roofs & pavements

Low • Moderate • High
Summary of heat-health modeling results

Temperature reductions often exceeded 1.0°C (1.8°F), and up to 2.0°C (3.6°F), a life or death difference.

25%+ reductions in heat-related deaths are possible, saving dozens of lives during the worst heat waves.

Oppressive air masses could be shifted to more benign ones.

Heat impacts of climate change could be delayed ~25-60+ years.
If urban forest cover can cool neighborhoods, why not just plant more trees?
Challenges of urban forest stewardship

- Rainfall averages and patterns (young trees must be watered!)
- A changing climate
- Pests
- Funding for planting vs. establishment
Behavior change study on urban forest stewardship

- Can a residential street tree stewardship program serve as a portal to increase knowledge and action around heat-health risk?
- Does engagement tailored to the community lead to better outcomes than one that is more generic?
- Are outcomes enhanced by message framing that emphasizes improvements to environmental health rather than public health?

**RESEARCH TEAM**
Edith de Guzman  |  UCLA and LA Urban Cooling Collaborative
Dr. Erica Wohldmann and Delmy Martir  |  CSUN
Luis Rodriguez, Dr. Yujuan Chen, and Pam Gibson  |  TreePeople

**Funded by**
Community Based Social Marketing (CBSM)

- Selecting Target Audience and Behaviors
- Identifying Barriers & Benefits
- Developing Strategies
- Pilot Testing
- Evaluation & Broad Implementation
Selecting target audience & behaviors

“The public” is not an audience.

AUDIENCE: Residents whose home is adjacent to a newly-planted street tree in the City of San Fernando

“Tree stewardship” is not a behavior.

BEHAVIOR: Check soil moisture - weekly Water w/ 15 gal - as needed

(Behaviors should be end-state and non-divisible)
Identifying barriers & benefits

**KEY FINDINGS**

- Trees are valued
- Barriers to tree stewardship are mostly *not* structural
- Perception that City is responsible for care
- Caring for trees is thought to be expensive
Developing strategies

INSTRUCTIONAL PIECE

COMMITMENT PIECES

REMINDER PROMPTS

Water Your Tree
- Check to see if the tree needs water.
- Dig down 3-4 inches into the soil and grab handful of soil.
- Squeeze the soil into a ball. If the soil doesn’t hold together, it is dry and ready for water.
- Slowly give the tree 15-20 gallons (three 5 gallon buckets) of water.

Regar su árbol
- Chequear si el árbol necesita agua.
- Sacar la tierra de un saco y poner en la tierra y agregar un puñado de tierra.
- Apriete la tierra en su mano y formarlo en bola.
- Si la tierra no se forma en una bola, indica que está seca y necesita agua.
- Muy despacio, déle 15-20 galones de agua (tres cubetas de 5 galones).

San Fernando
- We care for trees / Cuidamos nuestros árboles
- Did you know?
  - Did you know it takes a year to water your tree – as much as a carton of eggs!

San Fernando
- Green Streets, Cool Trees. The tree people

San Fernando
- Don’t forget to water your tree!
- Once a week! Check the soil around the tree. Dig your finger in the soil and see if it’s dry. If it is...
- Your tree needs water. Dig down 3-4 inches into the soil, and give the good watering of 15 gallons of water.
- Roughly 10-15 weeks ago, the leaves turned yellow and began to shed. Each tree lost 25 gallons of water. Every 2-3 weeks, give your tree 15 gallons of water. It’s a lot to give a tree.

Los Angeles Urban Cooling Collaborative
Pilot testing

**CONTROL GROUP**
Generic packet
Previously used successfully in smaller study in Huntington Park, southeast LA County

**ENVIRONMENTAL HEALTH GROUP**
Messaging highlights link between trees and improved environmental health
Tailored to San Fernando community

**PUBLIC HEALTH GROUP**
Messaging highlights link between trees and improved public health
Tailored to San Fernando community
Pilot testing

CONTROL GROUP

ENVIRONMENTAL HEALTH GROUP

PUBLIC HEALTH GROUP

LOS ANGELES URBAN COOLING COLLABORATIVE
Evaluation

12+ WEEKS OF OBSERVATION

- Collect soil moisture readings
- Observe presence of mulch
- Observe presence of weeds
- Rate tree health
- Note other observed issues
Preliminary findings  |  VALUES AROUND TREES

Trees are highly valued, and environmental messaging helps to solidify that

- Control Message
- Environmental Message
- Health Message

N=83
Residents are less willing to pay for watering after program engagement

N=83
Belief that tree care is the city’s responsibility is weaker after program N=83

Question: Some people think it’s mainly the government’s responsibility to help communities prepare for a disaster or an emergency. Other people think that it’s everyone’s responsibility. Using a scale of 1 to 7, do you think it is mostly the government’s responsibility or mostly your own responsibility?
Preliminary findings | PROTECTIVE ACTIONS IN THE HEAT

Public health messaging correlates with more protective actions taken during heat waves

N=83
Environmental health messaging correlated with slightly higher soil moisture, but soil moisture is often still too low for tree health

Moisture readings taken minimally once a week

N=115
Next steps

- Conclude survey data collection (pandemic-related delays)
- Collect additional soil moisture readings
- Conduct statistical analyses
- Compare to outcomes of prior pilot project
Implications

- In-person vs. passive engagement
- Generic messaging vs. tailored to the community
- Costs and benefits of community-based programs vs. hiring crews
THANK YOU

...and please go water a tree that needs it!
Kelly Turner
Assistant Professor, UCLA
Co-Director, UCLA Luskin Center for Innovation
@VKellyTurner

Hyper-Local Land Systems: Synergies and Trade-offs Between Regional Heat Island Mitigation and Pedestrian Thermal Comfort
More Than Surface Temperature: Mitigating Thermal Exposure in Hyper-Local Land Systems

V. Kelly Turner¹,² Morgan L. Rogers¹ Yujia Zhang³ Ariane Middel⁴ Florian A. Schneider⁴ Jon P. Ocón² Megs Seely⁶

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Cities are hotter because of how we build them, and they could be cooler if we build them differently.

**Regional Urban Heat Island**

Cities are hotter than proximate undeveloped areas.

**Albedo**

Moderates how much incoming solar radiation is radiated back as outgoing longwave radiation.
Cities are hotter because of how we build them, and they could be cooler if we build them differently.

**Human Thermal Comfort**

*Micro* conditions influence the human experience of heat.

**Mean Radiant Temperatures**

Net thermal exchange between a body and the objects that surround it.
Is surface temperature a good proxy for thermal comfort?

1. Diurnal variation?

2. Predicting simulated temperature? (Compared to sun exposure)

3. Relationship to land features? (Compared to MRT)
<table>
<thead>
<tr>
<th>CIVANO (Tucson, AZ)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach to sustainable urbanism</td>
<td>Solar Energy, New Urbanism</td>
</tr>
<tr>
<td>Biophysical Context</td>
<td>Arid</td>
</tr>
<tr>
<td>Development Type</td>
<td>Public-private</td>
</tr>
<tr>
<td>Size (Acres)</td>
<td>1145</td>
</tr>
<tr>
<td>Number of Households at Build Out</td>
<td>2600</td>
</tr>
<tr>
<td>Development Start</td>
<td>1981</td>
</tr>
</tbody>
</table>
Comparing Measures of Temperature

• Remote Sensing (RS)
  • NAIP (0.6m, Jun. 15 2019), Landsat (30m, May 27, 2019)
  • Land Cover Composition and Configuration, LST, Albedo, SAVI, LISA hotspots

• Field Observations
  • MaRTy cart 23 stop transects (May 25 2019), 7:00 – 21:00 MST
  • ST, AT, MRT

• Micro-climate simulations
  • ENVI-met
  • ST, AT, MRT

• Regression models to examine predictive power of climate variables

MaRTY – mobile biometeorology sensor – Ariane Middel SHADE Lab at ASU
Civano = Cool Neighborhood Microclimate

- More vegetation…
  …higher albedo…
  …most ‘coldspots’

- Little variation in LST, mostly desert ‘edge effect’

RS-LST at 10:00
- Min ~37 C
- Max ~44 C
Diurnal Trends

AT peaks late afternoon, little variability between sites

MRT high all day, lots of variability between sites

ST peaks midday, impervious/gravel hottest

LST at 10:00
- Min ~10 C
- Max ~55 C

RS-LST at 10:00
- Min ~37 C
- Max ~44 C
Satellites provide weak estimate of simulated temperature

<table>
<thead>
<tr>
<th>Simulated Temperatures</th>
<th>R</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>LST_08:00</td>
<td>-0.49</td>
<td>0.24</td>
</tr>
<tr>
<td>LST_10:00</td>
<td>0.4</td>
<td>0.16</td>
</tr>
<tr>
<td>LST_12:00</td>
<td>0.53</td>
<td>0.28</td>
</tr>
<tr>
<td>LST_15:00</td>
<td>0.39</td>
<td>0.16</td>
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<tr>
<td>LST_20:00</td>
<td>-0.72</td>
<td>0.52</td>
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<tr>
<td>MRT_08:00</td>
<td>0.65</td>
<td>0.42</td>
</tr>
<tr>
<td>MRT_10:00</td>
<td>0.63</td>
<td>0.4</td>
</tr>
<tr>
<td>MRT_12:00</td>
<td>0.63</td>
<td>0.39</td>
</tr>
<tr>
<td>MRT_15:00</td>
<td>0.64</td>
<td>0.41</td>
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<tr>
<td>MRT_20:00</td>
<td>-0.67</td>
<td>0.45</td>
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<td>AT_10:00</td>
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<td>AT_12:00</td>
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<tr>
<td>AT_15:00</td>
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<td>0</td>
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Regression results between Landsat8 LST (RS-LST) and the simulated LST, MRT and AT at hour, all models are significant at 0.001 level (2-tailed) except for AT_15.

Better predictor of MRT, than AT and LST

10:00 RS image strong, negative relationship with evening temp
Sun exposure better predicts hyper-local temperature

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<td>LST_08</td>
<td>0.05</td>
<td>0.003</td>
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<td>LST_10</td>
<td>0.69</td>
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<td>LST_12</td>
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<td>LST_15</td>
<td>0.48</td>
<td>0.23</td>
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<td>LST_20</td>
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<tr>
<td>MRT_08</td>
<td>0.99</td>
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<tr>
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<td>0.96</td>
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<td>MRT_15</td>
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<td>MRT_20</td>
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<td>na</td>
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<tr>
<td>AT_15</td>
<td>0.07</td>
<td>0.01</td>
</tr>
<tr>
<td>AT_20</td>
<td>na</td>
<td>na</td>
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Regression results between simulated shortwave radiation and simulated LST, MRT and AT at hour i at 30m resolution, all models are significant at 0.001 level (2-tailed) except for AT_08 and AT_15.

As expected, strong relationship with MRT

But also, variation in midday surface temperature

Source: The City of Melbourne via The Guardian 2017
Different Urban Land Features Predict LST and MRT

RS-LST Best Predictors
- Stronger relationships overall
- Land cover variables
- % building, % impervious, % trees
- Relatively similar all day

MRT Best Predictors
- Weaker relationships overall
- Morphology variables
- % trees, mean building and tree height
- Diurnal variation
Local heat planning needs nuance

• Define heat goal
  …UHI mitigation ≠ improved thermal comfort

• Always specify temperature type
  …especially what remote sensing estimates of LST can and can’t describe

• Ask when is space used
  …interventions perform differently throughout the day
Thank You!

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Ed Hawkins, #showyourstripes, mean temp deviation in CA 1985-2020
Thanks for tuning in!