Change in Heat Vulnerability and Land-use Influence

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This 1-year research is funded by the Connecticut Institute for Resilience & Climate Adaptation (CIRCA), as part of the Resilient Connecticut Project.

**Main Objective:** Understand the role of landscape changes on spatial-temporal variations to surface temperature.
- Classify the different types of landscapes considering form and permeability;
- Analyze land surface temperature data (LST), acquired from satellite images, to identify areas where heat islands are occurring;
- Understand the linkages between LST changes and landscape changes, to understand the relationship between temperature variation and land cover.

**Case Study:** Fairfield and New Haven Counties, Connecticut, USA
Project Phases

Phase 1:
- **Short-term analysis of LST** → focus on a 5-year timeframe to understand the current conditions for the studied region.
- **Assist CIRCA to deploy temperature heat sensors** → indicate different landscape typologies to collect air temperature and humidity data to evaluate apparent temperature.

Phase 2:
- **Long-term analysis of LST and LULC** → look at 20 years into the past to understand the relationship between LULC and LST changes to interpret the appearance and/or intensification of urban heat islands.

Phase 3:
- **Establish urban heat island intensity metrics** → interpret relationships between findings from satellite and in-situ measurements and identify performance capacity of both measurement methods.
Methodology

Local Climate Zones (LCZ) classification framework (Stewart and Oke, 2012)
• Classification beyond land use and land cover.
• Analyze landscapes in 3D to visualize the morphology and permeability of space.
• Bridge between urban climatology and landscape architecture.

• Machine learning approach that uses Google Earth Pro and SAGA GIS to develop LCZ classification based on aerial images (Google and LANDSAT 8). → 2015-2019 for current conditions.

Google Earth Engine → remote sensing and surface urban heat island analysis
• Land Surface Temperature → Code based analysis using methodology and code developed by Ermida et al 2020.
Results: Local Climate Zone Classification

LCZ classification framework applied to the state of Connecticut in accordance with Stewart and Oke (2012)
Results: Short-term Fairfield County

- Increase in human-based development in the Open Low Rise and Open Mid-Rise categories (orange colors above).
- Increase in the Sparsely Built category (peach color above).
Results: Short-term New Haven County

• Increase in human-based development in the Open Low Rise and Open Mid-Rise categories (orange colors above).
• Increase in the Sparsely Built category (peach color above).
Results: Long-term Analysis
Results: Land Cover Changes

Land Cover Changes in Fairfield and New Haven Counties, CT (2001-2016)

- Open Water
- Developed, Open space
- Developed, low intensity
- Developed, medium intensity
- Developed, high intensity
- Deciduous forest
- Evergreen forest
- Mixed forest
- Shrub/scrub
- Grassland/ herbaceous
- Pasture/ hay
- Cultivated crops
- Woody wetlands
- Emergent herbaceous wetlands

Total Area 2001: 748,247.35
Total Area 2016: 746,268.88

Loss (-)/ Gain (+)

- Open Water: -0.27
- Developed, Open space: +3.19
- Developed, low intensity: +4.28
- Developed, medium intensity: +10.34
- Developed, high intensity: +13.33
- Deciduous forest: -6.63
- Evergreen forest: -3.55
- Mixed forest: -4.93
- Shrub/scrub: -0.38
- Grassland/ herbaceous: +36.99
- Pasture/ hay: +29.75
- Cultivated crops: -11.74
- Woody wetlands: +4.18
- Emergent herbaceous wetlands: +0.55

Land Cover Types
Results: LST Changes

Land surface temperature change between 1999 - 2020
Results: Heat Sensor Network

Heat and humidity sensor network deployed in New Haven.

Sensor network composed of 20 sensors.

Deployed in August 2020, with consistent data retrieved between August and October 2020.

New round of analysis will be done for 2021.
# Results: In-Situ Sensors

<table>
<thead>
<tr>
<th>Local Climate Zone</th>
<th>Mean</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sensor</td>
<td>Air Temperature</td>
</tr>
<tr>
<td>Heavy Industrial</td>
<td>HI1</td>
<td>74.59</td>
</tr>
<tr>
<td></td>
<td>HI2</td>
<td>76.11</td>
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<tr>
<td>Compact Mid-Rise</td>
<td>CMR1</td>
<td>74.91</td>
</tr>
<tr>
<td></td>
<td>CMR2</td>
<td>74.96</td>
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<tr>
<td>Open Mid-Rise</td>
<td>OMR1</td>
<td>73.88</td>
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<tr>
<td></td>
<td>OMR2</td>
<td>75.18</td>
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<tr>
<td></td>
<td>OMR3</td>
<td>75.02</td>
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<tr>
<td>Compact Low Rise</td>
<td>CLR1</td>
<td>75.20</td>
</tr>
<tr>
<td></td>
<td>CLR2</td>
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<tr>
<td>Open Low Rise</td>
<td>OLR1</td>
<td>74.58</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>OLR4</td>
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<td>Sparsely Built</td>
<td>SB1</td>
<td>73.76</td>
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<tr>
<td></td>
<td>LP1</td>
<td>73.49</td>
</tr>
<tr>
<td></td>
<td>LP2</td>
<td>73.23</td>
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<tr>
<td>Scattered Trees</td>
<td>ST1</td>
<td>74.42</td>
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<tr>
<td></td>
<td>ST2</td>
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<tr>
<td>Dense Trees</td>
<td>DT1</td>
<td>71.66</td>
</tr>
<tr>
<td></td>
<td>DT2</td>
<td>72.17</td>
</tr>
</tbody>
</table>
This project shows the impacts of Land Cover Changes on Land Surface Temperature in the last 20 years in Connecticut.

- **Short-term analysis** → indicates variations in types of urban landscapes and aids in the understanding of the trends of urbanization in the last 5 years.
  - **Future expansion**: Is this trend true for the entire state?

- **Long-term analysis** → the gain of vegetation cover shows signs of cooling, yet intensification and expansion of urban heat islands have occurred in the west and inland in both counties.
  - **Future expansion**: How do these changes relate to policies and town planning? Is there a similar trend in the entire state?

- **New Haven Heat Sensor Network** → compliment the study by indicating the localized variability of air temperature and humidity in existing landscape typologies.
  - **Future expansion**: How are wind and shade contributing to cooling? Can these be signs of adaptation measures?


